SCHOOL SCIENCE
AND
MATHEMATICS

VOL. LII FEBRUARY, 1952 WHOLE NO. 454

EDUCATION—THE PRIMARY ATOMIC CONTROL*

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Mr. Chairman, Members of the Central Association of Science and Mathematics Teachers, Ladies and Gentlemen. I am honored with the opportunity to speak before this audience of educational specialists in the fields of the physical and biological sciences and the mathematical disciplines. I know it is with distinct regret that Commissioner Glennan found his fall and winter program of responsibilities and public appearances so full that it proved impossible for him to appear here today. As many of you know his sincere interest in the educational problems of today is exceeded only by his sense of patriotic duty which keeps him working in Washington on the vital problems of the Atomic Energy Commission. The City of Cleveland is to be congratulated on being able to furnish such a distinguished and able gentleman to fill one of the five memberships of the Commission.

I should like to discuss with you for a little while today those problems of an educational nature which seem to me to be pressing us hard for solutions; solutions much more adequate than we have been able to find in the past. Today we live in a world of change. The inspirational rallying statements of objectives of national leaders seem to be no sooner accepted, and the various national aims defined, than the rapid course of world events overrun the timeliness of such statements. For example we fought the First World War in all sincerity to "make the world safe for democracy." We fought the Second World War equally sincerely to remove the darkening scourge of dictatorship from the world and to banish fear. It is certainly unnecessary to

* Presented before The Central Association of Science and Mathematics Teachers, Cleveland, Ohio, November 23, 1951.

point out that the developments of the past six years have been such as to probably place the democratic way of life in as great, if not greater, jeopardy than it has ever been before, and to also result in an overall fear of future developments which seems to be well nigh universal in its scope and intensity. Does this mean, therefore, that military victories do not ensure the attainment of our national objectives? Is the cost of these military victories in terms of "blood, sweat and tears" always to be wasted and result in what appears to be a negative progress toward international peace and amity? Before attempting to suggest an answer to such questions, let me digress for a few paragraphs into a discussion of a field of human endeavor within which I believe we all will readily admit positive progress has always been the keynote, and within which even negative results are used to contribute positive components to progress. I, of course, refer to the field of your specialties, namely science in all its different categories.

All true science is based upon the application of the scientific method. Although it is usually impossible to prove at what instant or in what particular mind any new great basic human concept originates, it has always seemed to me that the scientific method had its practical origin in the great and fundamental work of Galileo about 1600 A.D. He it was, as you all remember, who had the inspiration and the energy to carry out carefully planned experiments which proved that in a vacuum all bodies fall with the same acceleration. The logical deductions from these facts enabled Newton to enunciate his laws of motion. Not an automobile or labor saving machine of any kind can be designed today which does not rest upon these principles first proved and stated by Galileo and Newton over 300 years ago. But these are examples of the scientific method. The method itself is the careful deductive reasoning applied to observed phenomena which results in the breaking down of a complex observation into simpler components. These latter in general will have connection with other observations and the desire is always to have the elemental components into which complex phenomena can be mentally decomposed of as wide applicability as possible. The next step in the scientific method is, of course, to synthesize those components which appear fundamental, and not incidental, to the observed phenomena into a statement, or general law, which can be tested by inductive experiment in other and widely varied sets of circumstances to check its implied truth. What a glorious record of permanent achievement has resulted from the continued use of this method by the various scientific disciplines during the past few centuries. Where can one find in this brilliant record such woeful failures in human progress as the political failures which have followed our recent military victories? Says Harold Moulton, Brookings Institution economist, "It appears

clearly to have been the influence of the great scientific discoveries of the seventeenth century which in due course provided the philosophical foundations for the system of free enterprise. The key to the great transition from regulated to free enterprise was found in the conception of 'nature's laws' with which the physical scientists were concerned." The imagination of man was stimulated by the newly discovered far reaches of the universe. Literature and poetry felt the effect. A specialist in the literature of that period attributes the difference in the types of poetic imagination revealed in Shakespeare and Milton to the new scientific knowledge about the constitution of the heavens and earth brought in between their dates by the telescope and the microscope. Ideas are thus always more potent than machines in shaping the world's destiny.

Let us approach a little closer to the present in our consideration of new ideas which are now shaking empires and bid fair to continue the alteration of the world's progress for some time. When Otto Hahn, working in his Berlin laboratory during 1938 upon logical extensions of the discoveries of Chadwick in England, Fermi in Rome, Curie in France, Einstein in Switzerland (to mention only a few), found that uranium atoms were split into parts, the sum of whose masses was less than the original whole, he created a new era. Little did he care or consider the political outcome of his academic discovery. This was part of the never ending battle for truth and for the true scientist represented an artistic triumph. We can epitomize the exaltation which must arise in the heart of a man who is responsible for such an outstanding advance by recalling Keats's *Ode* wherein he suggests,

> "Beauty is truth, truth beauty,—that is all
> Ye know on earth, and all ye need to know."

Atomic energy is another example of the logical result of applying the scientific method to the study of matter and energy. But in a broader sense it is much more than that. It is a breaking through of the frontier of knowledge of our world, bringing with it a dramatic extension of man's control of the primordial forces of nature. In World War II the use of atomic energy probably greatly aided in the termination of hostilities, and the existence of such weapons has undoubtedly been a deterrent to new agressions. But we should not lose sight of the fact that atomic energy is a beneficial as well as a destructive agent. Its known peacetime applications are many and new uses become apparent every day. Atomic energy converted to electric power and harnessed by industry might eventually bring the benefits of industrial production to those corners of the world where lack of the natural resources have thus far limited progress. Radioactive

isotopes, made in one of the wartime nuclear reactors, are already contributing new knowledge to medicine, biology, agriculture, the physical sciences, and industry, both in the United States and abroad.

Many new and diversified types of nuclear reactors for the production of fissionable material, for production of power, for the motivating energy to drive ships and airplanes are now being developed and some are under construction. Unfortunately, however, the real pressure behind this industrial progress is a munitions race in which we are now engaged. By all appearances our country and Russia are competing in what is doubtless the greatest military arms race in the history of the world. History shows that such contests have always led to war. Thus today's challenge to the human race is the necessity of finding ways and means of avoiding war while at the same time being forced to exert tremendous effort toward the production of military equipment of all forms, and the diversion of the most imaginatively productive years of our young men's lives to the dreariness of military training. I know of only one small piece of silver lining to this international dark cloud under which we at present live. In contrast to the ultimate uselessness of all military weapons of the past, if war does not require their expenditure our ever-increasing stocks of fissionable material can be readily converted to peacetime applications whenever it is deemed timely to do so. After a few years gun powder decomposes and must be discarded, but the lifetime of plutonium is about 24,000 years which, for practical purposes, can be considered infinite.

The question has been often asked—is there a defense against atomic bombs? I would answer, yes, the same defense that there is to a 30 calibre bullet which can be fired directly at your head. If you wait until the trigger has been pulled your chances are slim, but if you take some defensive precaution against the set of economic, social, philosophical, and religious circumstances which may create the environment within which the trigger is pulled you do have a possible defense. Atomic energy, as all other forms of energy, is fundamentally harmless. It is the mind of men wherein the danger lies.

You will probably have noted in my earlier discussion that the scientific basis of our knowledge of atomic energy all originated in work done in European laboratories. Our contribution in this country was to supply the engineering methods and mass scale production techniques which made these scientific discoveries of military importance. It has been of interest to me during two decades of university teaching and research to study the great tendency of those entering freshmen who were technically inclined initially to choose some branch of engineering as their major subject, rather than one of the basic sciences. Over thirty years ago Frank B. Jewett, then Director

of the Bell Telephone Laboratories, was stating that their experience showed training in physics, chemistry, and mathematics to be far better than extensive specialization in applied subjects. In these latter fields the universities were always far behind industry. Industry was willing to provide the training in specialized technical fields, and in fact had to do so, but it could not provide the basic background in the fundamental sciences and mathematics. However the great emphasis, in this country, on production rather than origination has resulted in the demand for operating engineers and only within the past few years has Dr. Jewett's preachings begun to bear fruit. It is obvious that the present great interest in science by the general public and its consequent result in the greatly increased enrollments in our science schools and colleges is mainly due to the startling applied results flowing out of uranium fission. Let us examine this point a bit further. Why should an outstanding application of a new scientific principle not cause more interest in the study of scientific applications rather than science itself? I believe the answer to this lies in the fact that just after the war the engineering schools, in general, were not equipped with properly trained people who could teach the principles. The engineering techniques were mostly of a classified nature and were not released to educational institutions of any type.

Up to World War II the engineering schools, with a few marked exceptions, were giving the same training fundamentally as had existed for at least twenty years. A very minimum of basic science and mathematics with practically none of the humanities, literature, economics or the other disciplines necessary for a broad cultural background. After the first year or two most engineering curricula were completely prescribed for the student and consisted mainly of applied technology. The graduates from these courses were successful in utilizing great quantities of data tabulated in handbooks and reducing these to a practical form on the drafting board, but they had had practically no experience in being confronted with problems the solutions to which could not be found in handbooks or deduced from a large set of memorized formulae. Those few exceptional students who, after four years of this stereotyped training, realized their need for experience in original research, went on to graduate work where they usually specialized in one of the sciences but still did not experience the broadening inherent in a familiarity with the humanities and social science.

There are now signs, since World War II, that many engineering schools have recognized the narrowness of their former completely prescribed courses of study. Many are adding a fifth year to allow more time for cultural studies and basic science.

The great increase in the physical sciences is tending to develop at

present the same type of difficulty under which the engineers have so long labored. This is the tendency to keep all the old subjects in the prescribed curriculum and simply add the newer ones. With the additional boundary condition of maintaining a four year undergraduate course, this can only result in a pushing out, or disastrous reduction in, the broader cultural studies so necessary for the well rounded individual.

I would further suggest that we are overemphasizing the university and college as the primary sources of properly trained people. In the vast expansion of the research and development programs now being promulgated by the military services, as well as the Atomic Energy Commission, there is an ever increasing need for all categories of technical training. For each scientist or highly technical worker there must be from 3 to 6 assistants of the type of electronic technicians, skilled machinists, draftsmen, computers, and general laboratory helpers who require the type of training most readily and satisfactorily provided by trade schools or junior colleges. I believe we have too often spoiled a boy with a great natural mechanical bent to do things with his hands, and who would be potentially a top flight machinist or optician, by encouraging him to try to master all the academic background of an engineer or scientist. This has many times bored him, he has been able to do only a third or fourth class job, yet it has resulted in instilling in his mind the class consciousness requiring him to demand a white collar job and to not develop his best latent talent. This country has never produced the top flight instrument makers and optical workers which Germany in the past has developed. At the present time it is very doubtful whether we can find sufficient skilled talent in this country to produce some of the difficult optical components which we need in at least some of our tanks. There is no question about our great need for skilled mechanics and technicians. These can only be produced quickly, in the volume required, by greatly increased trade school emphasis. We also do need in increasing numbers well trained engineers and scientists. The latter, I believe, we can and will produce if sufficient good judgment is used in recognizing the need for deferment from the routine military service of those properly qualified for the scientific work which is equally important to the country.

But these latter problems of which I speak, although of great immediate importance, are short range in nature. Are we ever to progress along the lines to which so much effort has been directed during the last three decades? I refer of course to the problem of peaceful settlement of international disputes. A previous colleague of mine, a professor of history in a large western institution, has made a study of the frequency of occurrence of wars over the entire world as a func-

tion of time. He finds that in the frequency of wars, large and small, instead of turning out to be a decreasing function of time the reverse is the case, and particularly since the turn of the present century the frequency function seems to be a very rapidly rising curve.

It is well recognized that in large and small disputes the most effective way of resolving the argument is to get the opponents around a table and examine the problem from all viewpoints. This, of course, is the hope of the entire United Nations' concept. Let us, however, examine the problem a little closer. Present means of communication being what they are there is no longer any difficulty in promptly getting flow of information in both directions from the various seats of government to conference tables anywhere in the world. But this is really only a small part of the problem. The great variations in cultural background, the different standards of living, the various religious forms, all form a traditional framework, different for each country, upon which the immediate circumstances surrounding any dispute have to be hung for examination. The conclusions drawn from similar sets of facts will in general be different due to these different traditional backgrounds. Even in the field of the physical sciences a common set of observations are often times "explained" differently by the chemists from their viewpoint than by the physicists from their somewhat different traditional viewpoint. So it is not at all surprising that international disputes can and do arise over combinations of circumstances which in the light of any one set of nationalistic traditions seem to allow only one more or less obvious conclusion.

Do we make any permanent progress along the pathway toward establishment of a universal set of traditions by depending upon military power? Quite obviously not. Yet during the long interim period during which the world approaches an ideal solution it is equally obviously often necessary to rely upon such strong arm methods. During the present period of the world's history it is only too evident that the efficiency of the militarist is far superior to that of the diplomat in the short range temporary solution of problems. But is it sensible to ignore early stages of exploratory research on a problem and concentrate entirely on production? Many industries have fallen behind the wheels of progress by such neglect. In the field of international progress it seems to me we do very little research. What type of problem would one suggest in this field that would seem promising of reward? Let us examine first what financial support of research exists in this country at present.

At present it is estimated that we are spending somewhere about one and one-tenth billion dollars yearly on military research and development out of a total military budget of about 60 billion. This yields almost 2% of the military budget for research and develop-

ment. By joint agreement the Army, Navy, and Air Force in turn have each agreed to allocate 6% of their total research and development budget annually for the support of basic research. Thus we arrive at a figure of 66 million dollars which the three military services have jointly agreed to put into basic research.

The Atomic Energy Commission for the past three years has had a fellowship program supporting work in the physical and biological sciences. During the past year approximately 450 fellows, both post and pre-doctorate level, have been supported at a cost of about $1,500,000. A very small fraction of these have been for study abroad; the major fraction are for support of promising young scholars to carry on research in the universities and colleges of this country.

During the 1920's and early 30's, the Rockefeller Foundation financed the National Research Fellowships which provided support for post doctorate research fellows in the physical, biological and mathematical sciences. The great value of the Rockefeller Fellowships is attested to by the fact that many of our present directors of important laboratories, both industrial as well as academic, and many present university presidents, were recipients of those awards. The Guggenheim Fellowships have annually also provided for a few scholars and artists to study and travel abroad.

But the point I want to make here is that although the worth of such fellowships has been amply demonstrated by their providing broadening experience for the potential leaders of this country's science and art, we have never undertaken this demonstrably valuable endeavor on anywhere near the scale which we are willing to provide for military budgets. Compare the paltry 2 to 3 million dollars yearly, outlined above, as our present level of fellowships with the 66 million dollars for military basic research. Thus a clearly indicated experiment in international relationships would be to establish say 10,000 fellowships, in all fields of human endeavor, which would provide the opportunity for the recipients to study abroad in the country, or countries, of their choosing. They would be required to write a thesis or report at the termination of their fellowship which would be submitted for publication in a government research journal established for just this purpose. But the chief value of a program such as this would be greater awareness which could be developed thereby in the citizenship of this country of the problems of everyday existence in all walks of life in other countries. It would certainly be hoped that such a program as this, if it were established by this country, would result in similar programs being instituted by other nations of the world. Such a cross fertilization of personal contacts on a broad basis and in all fields of endeavor could not fail to bring about a closer understanding and real appreciation of the aims and hopes in the

hearts of men throughout all civilization. A program of the size indicated would at present rates of fellowship support cost about forty million dollars annually; about half of present costs of an atomic reactor and about the cost of a modern submarine. There can be no question of the greater long term utility of such a program to aid in insurance of world understanding, and resultant peace. This is education in the real sense of increasing worldwide understanding of the social, physical, psychological, and religious environment which we find ourselves. It represents a logical attempt to apply the scientific method of careful observation of facts and deductions therefrom to the field of social relationships in which there are as yet no quantitative units of measurement. It provides the basis for close personal contact and establishment of mutual confidence between greater numbers of educated people of widely varying cultures than has as yet been accomplished.

A few weeks ago while standing on a ridge in the Nevada desert observing an atomic explosion, I was struck by the observation of a friend standing next to me. Just as we lowered our dark glasses at the termination of the existence of the brilliant ball of fire, he observed "How much simpler our lives would be if the Almighty had directed that, instead of an average of somewhat greater than 2 neutrons being released for each uranium fission, there was to be slightly less than 2!" This, of course, would result in the impossibility of a chain reaction. But in all honesty we must admit that our real danger certainly does not lie in the beautiful regularity of nature's laws which do allow such things as neutron chain reactions. Our danger lies in the mental chain reactions which establish themselves in human minds as a result of misunderstanding between the large groups of the world's population. It is true that much of such misunderstanding is the result of deliberate operations by groups which exist from time to time in many countries, and who strive to gain personal power for themselves by such misleading of the majority of their national populations. The establishment of a first-hand wide scale appreciation of the facts of social and economic life in all countries by large sections of cultural leaders in other countries certainly seems to be the only hope of ultimately removing international suspicions. It is a long range experiment, its cost is small in comparison to present expenditures of all the leading countries of the world, its promise of ultimate success is bright. It is the form of education which can provide real atomic control and protection.

Copies of *A Half Century of Science and Mathematics Teaching* are still available. Write Ray C. Soliday, P.O. Box 408, Oak Park, Ill. Price $3.00.

A SIX-SIDED HEXAGON

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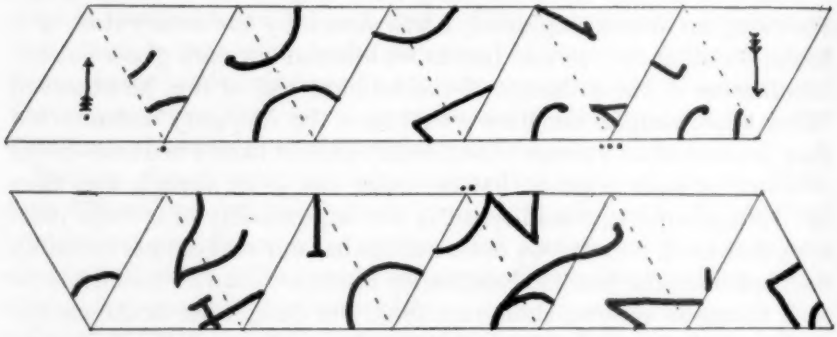
As is well known, most hexagons have only *two* sides, a front and a back: but it is possible to construct a hexagon with *six* sides, and these sides numbered 1, 2, 3, 4, 5, 6, at that!

You need a strip of light cardboard, white on both sides, nearly seven times as long as it is wide (the exact ratio is $11:\sqrt{3}$), which is to be marked off into ten equilateral triangles and then given the heavy markings, on both sides, as shown in the figure. These heavy markings afford the numbers, and it is well to put them in tentatively with pencil, and give them the broad inking in after the completed hexagon shows how they form a central figure.



The full lines are to be scored so that the cardboard can be bent *down* along them, and the dotted lines indicate where the scoring is on the other side so that along the dotted lines the cardboard will bend *up*.

Taking the strip so that the side with the arrows is uppermost (dotted arrow at the left), bend down along the line marked with one dot, then bend down along the line marked with two dots, and then down along the line marked with three dots. Then paste together the two triangular sides marked with the arrows, making the arrows overlie each other exactly.

You will now find that you have a hexagon with the upper side marked "1" and the under side marked "6." To find the other sides, you must fold so as to bring three alternate corners down together, and then open from the top: this will give you the "2." Again fold down and open, and you get the "3." Turn over, and you have the "4." Go on as before to get the "5" and the "6."

Reason is omnipotent when it has love for an ally.—COUNT CAVOUR.

GOOD ENGINEERING MATERIALS SHOULD NOT BE MISUSED

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New names of important materials are appearing in our everyday reading and in the technical literature. These include both ferrous and non-ferrous metals, plastics and even substances found abundantly on the surface of the earth. It has been said that almost anything can be made but that it is the particular problem of the engineer to see that it is made economically. The engineer is constantly making decisions involving the selection of the most suitable material and the proper shape and the best design. Moreover, he must arrive at a workable solution in a reasonable time so that people may use his product. There is always an opportunity to pursue the problem of making later improvements.

This article literally hits some high spots by naming some extremely interesting new materials which have exhibited outstanding properties such as high strength, low density, excellent resistance to chemical deterioration and destruction by high temperature.

DUKTILIRON is the trade name of the International Nickel Company for the process it will license to common grey iron foundries for making a new high-strength and high-elongation iron out of their regular grey cast iron. This will be accomplished by adding a magnesium alloy (almost any alloy) containing about 15 per cent Mg, to the grey iron at 2750°F., in the ladle before the iron is poured. Some of the magnesium comes out to the surface of the molten iron as slag but about 0.6 per cent Mg is residual in an uncombined state. The amazing result is the production of spheroidal graphite with consequent marked improvement of mechanical properties.

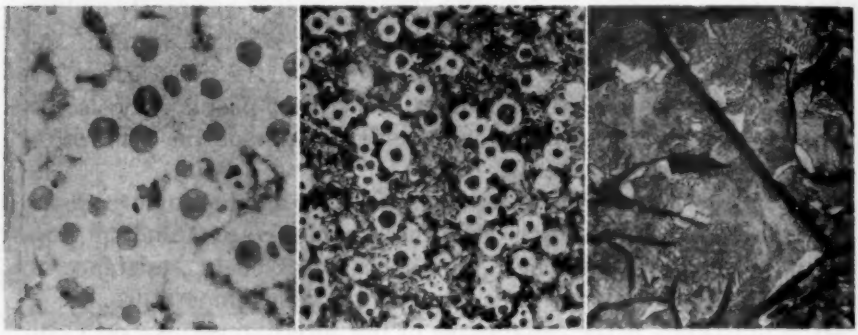
The International Nickel Company has made great research advances over the original patented process of Nodular iron by the British. In the British process Cesium instead of Magnesium was used.

In the research program on Duktiliron, it has been found that the tensile strength increases as the content of silicon is increased from 0 to 5.5 per cent; and the ductility decreases as the amount of carbon increases from 2 to 4.5 per cent. The maximum tensile strength of 110,000 lbs./sq. in. and 30 per cent elongation has been obtained by subjecting the material to a heat treatment.

Duktiliron is intended to compete with the usual malleable iron. It is cheaper even now. Malleable iron has a tensile strength of about

100,000 lbs./sq. in. and an elongation of 18 per cent. Malleable iron must be cast white iron, which requires chilling and therefore sections up to a maximum of only about 2 inches can be made. Also the malleabilizing treatment requires about seven days. Duktiliron is in all respects superior to common grey iron castings, except cost. It now is perhaps 30 per cent more expensive than grey iron. A good grey iron containing 1.5 Ni and 0.5 Mo has a tensile strength of 65,000 lbs./sq. in. and less than 0.5 per cent elongation.

The disadvantages of DUKTILIRON are the necessity for the high soaking temperature of 2750°F. in the cupola or electric furnace and the necessity for using a basic furnace lining. Some success has been obtained recently wherein the usual acid furnace lining was employed.



a b c

a. DUKTILIRON (As Cast). Showing spheroidal graphite.
b. *DUKTILIRON* (Annealed). Showing numerous spheroidal graphite particles.
c. *COMMON GRAY CAST IRON*. Showing flake graphite (like Corn Flakes).

Annealing at 1650°F. and cooling the parts in the furnace has improved the mechanical properties of DUKTILIRON. This process is accomplished within a 24-hour period.

An extensive research investigation for the International Nickel Company is being conducted at the University of Michigan.

SEMINOLE is the high-strength steel produced by the Allegheny Ludlum Steel Corporation. A typical chemical analysis shows 0.49 C, 0.25 Mn, 0.69 Si, 2.17 Wo, 1.54 Cr and 0.25 Va. This material is an especially high shock-resisting tool steel. When it is properly heat treated by quenching in oil from 1750°F. and drawn at 600°F., it attains the tremendous strength of about 297,500 lbs. per sq. in. It remains elastic almost until breakage occurs, making it an excellent spring material.

ALUMINUM and its alloys can hardly be called new materials. They have such a high strength and low weight that appropriate recognition should be given. Duralumin designated as 17 ST by the

Aluminum Company of America is easily the most widely known aluminum alloy. Containing 95 Al, 4 Cu, 0.5 Mn, and 0.5 Mg it reaches a value of 58,000 lbs. per sq. in. ultimate strength in tension. It has a density of about one third that of steel. It deforms elastically about three times that of steel. Great technical advances have been made within the last year in welding and soldering aluminum alloys.

MAGNESIUM has been alloyed by the Dow Chemical Company into many commericially important products. Dowmetal FS-1 is fabricated into sheets, rods and tubing containing 96 Mg, 3 Cu, and 1.0 Zn, has an ultimate strength ranging between 35,000 to 42,000 lbs. per sq. in. It is less than one-quarter the density of steel and the flexibility of magnesium alloys is a little over four times as great as steel.

GEON plastic is produced by the B. F. Goodrich Co. It is polyvinyl chloride which is variously added to plasticizers. The Houghton Laboratories, for example, which is one of the several concerns which compound the Geon plastic, markets two products. Hysol 3000 is a soft rubber-like material when properly heated in molds to about 350°F. for about an hour. It has a strength of about 2400 lbs. per sq. in. and a density of 0.0425 lb. per cu. in. A much firmer substance is Hysol 6000 which has a strength of about 11,370 lbs. per sq. in. Both of these materials are reasonably resistant to chemical action.

SILASTIC is a Dow Corning silicone rubber product possessing great ductility, resistance to chemical deterioration and capable of withstanding extreme temperatures. It can be used from −70°F.to 500°F. It resists weather, hot oils and chemicals. It can be molded and extruded and has a Durometer range from 45 to 85. Its tensile strength is in the range from 360 to 700 lbs. per sq. in. and it has an elongation from 85 to 250 per cent. It is $1\frac{1}{2}$ times as strong as organic rubber. Silastic is not competitive with organic rubber in the temperature range from −40°F. to 200°F. The density values range from 0.043 to 0.083 lb. per cu. in.

ORLON, produced by E. I. DuPont De Nemours & Co., is a most remarkable plastic acrylic fiber. It is obtained in the from of a skein of continuous filament yarn of high strength, ranging from 71,000 to 79,000 lbs. per sq. in. It has an elongation of 15 to 17 per cent. Orlon resists heat up to 300°F., certain chemicals, and sunlight, making it excellent for textiles. It is replacing Nylon for use in parachutes and airplane towing cords. Under exposure to outdoor elements, Orlon will outlast many times such materials as silk, rayon, and cotton. The combination of high strength and a low density of 0.042 lb.

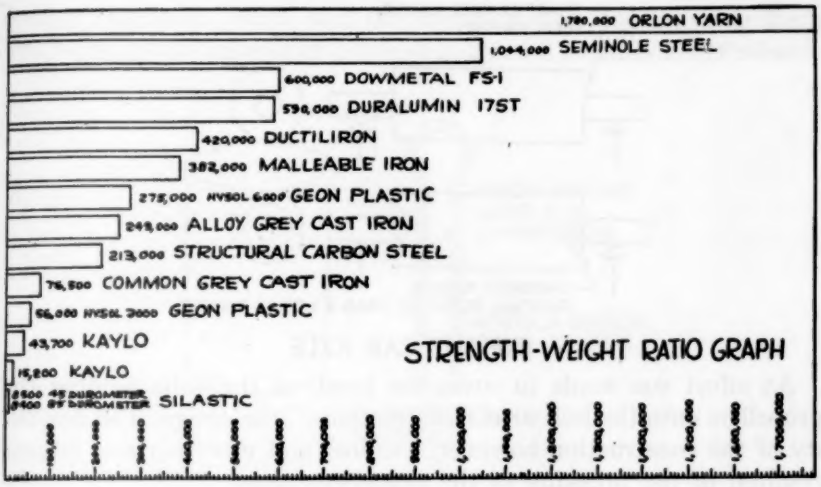
per cu. in. makes Orlon one of the finest commercial materials based on a strength-to-weight ratio.

KAYLO is the new insulating material manufactured from sand by the Owens-Illinois Glass Co. It is made in the form of structural fireproof insulating block with or without steel reinforcing. Although Kaylo is intended to exhibit reasonable resistance to flexure, this material is essentially intended for compressive loadings. The density is about 0.115 lb. per cu. in. Other forms of Kaylo are in heat insulating block, firedoors, pipe insulation, roof tile and laminated panels.

One of the many ways by which the engineer evaluates materials is by the so-called strength-weight ratio. Although it is most common to base these ratios on the working or safe stress which may be some arbitrary fraction of the ultimate tensile strength, for the purpose of this discussion the accompanying table shows the ratio of the ultimate tensile strength and the density. Besides considering other factors such as cost, rigidity, space requirements, availability and the like, the engineer frequently selects the material which gives the highest strength-to-weight ratio. This consideration is particularly important in the design of airplanes, ships and other transportation devices.

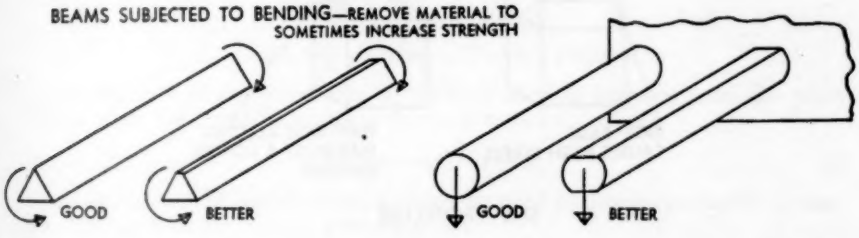
Material	Tensile Strength (lbs. per sq. in.)	Density (lbs. per cu. in.)	Strength-Weight Ratio	Rank
Ductiliron	110,000	0.260	420,000	5
Malleable iron	100,000	0.260	382,000	6
Alloy Grey Cast Iron	65,000	0.260	249,000	8
Common Grey Cast Iron	20,000	0.260	76,500	10
Seminole steel	297,500	0.283	1,044,000	2
Structural carbon steel	60,000	0.283	213,000	9
Duralumin, 17ST	58,000	0.098	590,000	4
Dowmetal, FS-1	38,500 (av.)	0.064	600,000	3
Geon plastic				
Hysol 3000	2,400	0.0425	56,000	11
Hysol 6000	11,370	0.0413	275,000	7
Silastic				
45 Durometer	360	0.043	8,400	15
85	700	0.083	8,500	14
Orlon yarn	75,000 (av.)	0.042	1,780,000	1
Kaylo	175	0.0115	15,200	13
	500 (comp.)	0.0115	43,700	12

Certainly some brief remarks should be made about shapes. It is well known, for example, that a tubular member is generally well adapted to situations involving compressive loadings. I-beams for bending loads and simple prismatical bars for cases of tension loadings.



When a failure occurs in a machine or structure, it is usual to replace the part by one having just a little more material. By means of several illustrations, it will be readily understood that not only more material may make the structure weaker but actually it is sometimes better to remove material to improve the strength.

A prismatical beam may be subjected to bending as shown in the accompanying figure.

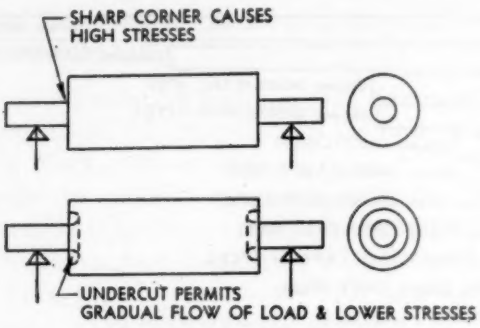


When the beam is bent the upper surface is stretched in tension. If there is only a small amount of material in this location as in the cases of the circular and triangular cross sections, it is better to remove the material which would otherwise be most highly stressed.

Most commonly actual machines and structures require more complicated designs involving connections of members of different sizes.

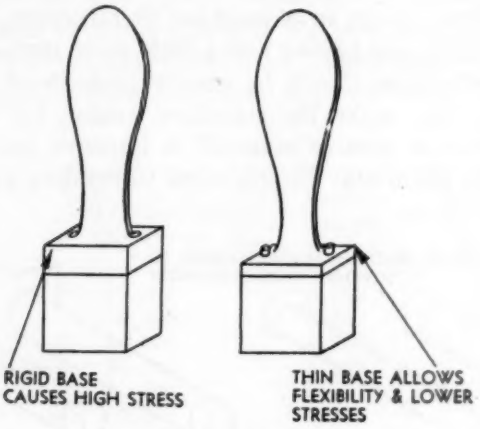
By two slightly more complicated illustrations, the removal of the material is recommended in the vicinity of the junctions of small and large cross sections so as to allow for greater flexibility and lower stresses. The figure (see next page) shows a freight car axle.

The propellers of lake freighters were found to break off after metal had been added in new designs as shown in the figures.



FREIGHT CAR AXLE

An effort was made to cover the heads of the bolts holding the propellers onto the hub so as to "streamline" the design. The flexibility of the construction however, was lost and vibration and fatigue resulted in the breaking of the propellers.

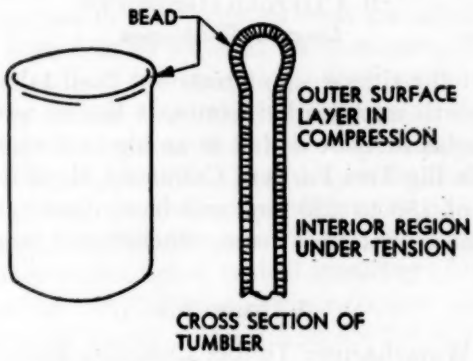


SHIP PROPELLER

The "Safe edge" drinking glass made by the Owens-Illinois Glass Co. is strengthened by blowing air onto the upper edge of the hot glass. This produces a favorable combination of surface compression and interior tension. The resulting tumbler will withstand about seven times the shock compared with an ordinary tumbler.

One of the greatest examples of the misuse of good engineering materials is in the case of concrete in sidewalks, curbs and pavements. Concrete, like most materials, expands and contracts due to the rise and fall of temperature. Concrete, unlike most materials, grows under the continued exposure to wet and dry weather conditions. The provision for expansion is frequently made to account for temperature fluctuations but any casual observer will detect countless

broken sidewalks, curbs and pavements due to the crushing loads produced by the growth of concrete subjected to moisture. Probably



an obvious remedy for this situation is to provide adequate drainage under the concrete and an effective protective coating on the upper surface of the concrete.

AN APPLICATION OF THE POINT-OF-DIVISION FORMULA

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The ordinate of the point $P(x, y)$ dividing the line segment from the point $P_1(x_1, y_1)$ to the point $P_2(x_2, y_2)$ in the ratio $r_1:r_2$ is

$$y=(r_1y_2+r_2y_1)/(r_1+r_2). \tag{1}$$

As an application of this formula, suppose we need to interpolate in the accompanying table, or any similar numerical table.

TABLE

Annual Rate of Interest	3%	3.5%
Amount of \$1 for 10 years	1.3439	1.4106

Suppose we want the compound amount of \$1 for ten years at, say, 3.36%. The amounts given may then serve as ordinates of the points P_1 and P_2. Taking $y_1=1.3439$, and $y_2=1.4106$, we may let $r_1=0.36$ and $r_2=0.14$ in (1). Then y becomes the required amount of \$1 as obtained by linear interpolation.

$$y=(0.36[1.4106]+0.14[1.3439])/(0.36+0.14).$$

$$y=2(0.50782+0.18815).$$

$$y=1.3919.$$

This result is very conveniently obtained if a computing machine is available.

TALES OF TALL TIMBER*

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The order of the title is significant: not "tall tales" but "of Tall Timber." In north west United States, if timber is tall, it is, most probably, Douglas fir. Not as tall or as big in circumference as the trees of Sequoia Big Tree Parks of California, these firs do, however, reach heights of 180 to 250 feet and have diameters from five to twelve feet. Individual trees have unbelievably large lumber content.

A Jumbo Fir

In 1944 the Weyerhaeuser Timber Company harvested their prize lumber find, familiarly known as "The Big One." It was approximately eleven feet in diameter at its base; had a total usable log length of 196 feet and produced 71,542 board feet of lumber of about 300 tons weight. It required an eleven car train to haul it from the timber to the mill. This particular tree was 680 years old. Its start antedated the discovery of America by some 230 years. The total tree height was probably near 225 feet since the upper thirty feet was not used for lumber; too many knots etc. Compared with the "General Sherman," one of the much publicized trees of California's big trees, the California tree is thirty or forty feet higher, is twice as large in diameter and was about 4000 years old at the birth-date of "The Big One."

Sylvan Survival

Trees that can live hundreds or thousands of years would appear to have approached immortality. However, all fir seeds that sprout do not become tall and profitable timber. As one writer[1] puts it, "all over the United States the number one enemy of trees is insects and disease. . . . The blister rust, the pine beetle, the hemlock hopper and other blights and bugs represent more danger than billowing smoke to the forests of the west."

Evergreen States

Though percentage loss due to fires is not as great as to "blights and bugs" the publicity given to forest fires would place them first in the esteem of the public. Washington's state slogan, "Help keep us green" contributes to the public's awareness of this threat to the state's chief resource. The summer of 1951 was considered that state's

* This is not an essay on lumbering but rather some random paragraphs of interest about trees.
[1] James Stevens of Seattle, Wash.

worst drought in the last thirteen years but this water shortage made headlines, not in comments on crops losses, but rather in constant warnings of fire hazard by reason of low humidity. At such times loggers are permitted to work only on what are called "the hoot owl shift," that is from four to ten A.M. each morning. Whether it was due to incessant radio or news paper publicity, or the enforcement of no rubbish fires or the restriction of logging to those very early morning hours, at the summer's end the state supervisor of forestry considered that his field men and their helpers had been notably successful. They had kept the fired acreage down to a 35,400 acre loss out of the state's total 12,500,000 acres. "They did this," he said, "In spite of a summer with a below critical humidity (30 per cent) more days and hours than any other year since records were kept."

Some of the many causes of forest fires are listed as: "Fire bugs"; debris burners; smokers; railroads; campers; lightning, etc. "Fire bugs," those individuals who set fires for the fun of it, lead with credit for 40 per cent of the fires. Smokers are said to be responsible for starting 17 per cent.

Snag Logging

Fires inflict heavy damage to lumber forests but the destruction is not always total. In the early 1930's a fire known as the Tillamook Burn in Western Oregon killed timber on over 300,000 acres. Since that time logging of the snags, left by the fire, is estimated to have salvaged 8,000,000,000 board feet of lumber. In doing this clean up some 3,000,000 snags were removed and utilized. The snags thus put to use yielded, on an average, 2,670 board feet per tree stump.

"No Fire, No Fir"

The forest fire, in a sense, seems to be the midwife to the successful propagation of the north west's Douglas fir. The expert[2] says, "Douglas fir can not compete with western red cedar and western hemlock whose ability to endure shade permits them to form an under-story which crowds out the less shade-enduring Douglas fir. . . . So without fire or logging to interfere . . . a region left for 600 or 700 years would have its Douglas fir crop very greatly reduced." It might be said, "No fire, no fir."

Bear Barkers

But bugs, blight and fire are not the only hazards to a fir crop on the mountain side. Report has it, "For some reason, that foresters and game biologists can't explain, the Olympic Peninsula (bear) has

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[2] Botanical Survey of the Olympic Peninsula, George N. James, University of Washington, Seattle, page 30.

recently developed a strong appetite for tree sap. . . . The bears seem to prefer Douglas Fir sap. After coming out of hibernation, in early spring, he claws the bark from young Douglas fir, hemlock spruce and cedar trees. Then he licks up the sweet sap as it oozes from the wood. Many of these trees, completely girdled, wither and die.

"Since 1945, on some . . . Douglas fir stands, bears have killed 100 trees to every one killed by fire. In some areas you can trace early spring wanderings of a bear by the dead or dying trees he left in his wake.

". . . In 1950, an aerial survey of timber . . . (in the Olympic Peninsula, found) evidence of bear damage in 61,000 acres."

Bruin's sap guzzling has the Washington State authorities, as well as the lumbermen, up in arms—and that in more than a figurative sense.

Farming Trees

Conservation is a word in the vocabulary of most intelligent citizens of the United States. When applied to timber it is translated into the phrase, "forest management," and the unit for such practice is known as a "Tree Farm." This management involves, among other activities, treatment to control bug and blight damage, organization to prevent and fight fires, cooperation with state game departments in the depopulation of the bears of areas where they are seriously damaging the timber and directing all logging operations with an eye to both successful removal of the marketable timber and the protection of the younger growth that it may become a profitable lumber source in the years ahead. A recent United States Forest report says, "Only eight per cent of all timber cuttings on private lands can be classed as good; 27 per cent as fair and 64 per cent as poor or destructive." On the other hand it says, "Many lumber, pulp and paper companies are doing a good job of forest management." In general, it considers "saw timber still is not being grown as fast as it is being used. . . . (We are) not taking good enough care of (our) forestry resources."

HIGH MOUNTAINS RISE FROM PACIFIC'S FLOOR

Thirty-five major sea mountains, from 3,500 to 12,400 feet high, rise from the floor of the Gulf of Alaska, two oceanographers of the U. S. Navy Electronics Laboratory report.

The mountains are divided into two area-wide groupings. One type is of volcanic origin and the other was formed orogenically, that is when the earth's crust folded. Drs. Henry W. Menard and Robert S. Dietz believe that the volcanic mountains formed along a major rift in the crust. Most of the soundings on which their study is based were made by the U. S. Coast and Geodetic Survey and the Hydrographic Office of the U. S. Navy.

THE FIELD TRIP—A TECHNIQUE IN NATURAL SCIENCE TEACHING

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"You wish to teach this child geography and you provide him with globes, spheres, and maps. What elaborate preparations! What is the use of all these symbols; why not begin by showing him the real thing so that he may at least know what you are talking about?"

The words were French, the author Swiss-born, the idea revolutionary. These were sentences from the pen of Jean Jacques Rousseau, a paragraph from a philosophical romance written in 1762, entitled "Emile," which in reality was a treatise on education. Rousseau's contemporaries liked the novel to the extent that they exiled its author from France partly on the strength of it. Today, "Emile" or "De l'Education" is looked upon as an educational classic, and many of the ideas set forth therein have become incorporated into our pattern of teaching.

Each spring a group of students and faculty from the Forestry School at Colorado A & M College close textbooks and offices, gather together notebooks, binoculars, cameras, field manuals, and bedrolls, and for a period of several weeks exchange the campus for the out-of-doors. This is not, as some might suspect, a vacation or pleasure trip. It is the culmination of one of the educational ideas advocated by Rousseau almost two hundred years ago, the field trip which this French philosopher introduced to an awakening world of science.[1]

The forestry seniors on the spring field trip are, to paraphrase Rousseau, being shown "the real thing.". . . And were we to question each returning senior about the habitat of Merriam's turkey in southern Colorado, techniques of deer censusing in White River National Forest, or trout rearing at the Buena Vista hatchery, we would find that he knew what we were talking about and answered not in memorized words from a printed page but in a voice strengthened by contact with the real thing through the medium of the field trip.

In America as recently as 1917, the field trip had, to quote the author of a textbook on science teaching (Twiss, 1923), "not as yet come into very general use." It is easy to imagine the disfavor which

[1] Actually, the field observation idea antedates Rousseau (Hoban, *et al.*, 1937; McKown & Roberts, 1949). Socrates and Aristotle made apparent use of the field method in their teachings, Johann Comenius, a Moravian bishop and educator of the seventeenth century, recommended that "People must be taught to get their knowledge, as far as possible, not from books but from the earth and sky . . . ," and even the poet Alexander Pope, in his famous poem "Essay on Man" (1733), urged:

"Thus then to man the voice of nature spake—
Go, from the creatures thy instructions take;"

confronted Rousseau's idea when originally promulgated. Not until after 1805 was the field trip actually incorporated as a teaching device, when Johann Pestalozzi, a Swiss educational reformer, introduced its use into class work at his school in Yverdun near the southern shore of Switzerland's Lake Neuchatel. Pestalozzi, like Rousseau, advocated a learning process which began with observation and thence passed through consciousness to speech (Anonymous, 1947).

During the course of the nineteenth century the field excursion became a common teaching device in Switzerland, France, and Germany. When Jean Louis Agassiz, naturalist, geologist, and teacher, came as professor of natural history to the University of Neuchatel in 1832, he undoubtedly encountered the field study tradition initiated twenty-five years earlier by Pestalozzi only twenty miles to the south. It is small wonder, then, that when Agassiz accepted the professorship of zoology at Harvard University in 1848, he brought to this country the idea "study nature, not books."

Execution of Agassiz's motto effected a complete revolution in the study of natural history in the United States. His favorite expressions, "If you study nature in books, when you go out-of-doors you cannot find her," "It's not text-books we want, but students," "The book of nature is always open," and "Strive to interpret what really exists" remind one of the recommendations of the earlier Rousseau (Jordan, 1947).

Like Pestalozzi, Agassiz contributed in practice as well as in writing to the advancement of science teaching, for the old barn on Penikese Island off New Bedford, Massachusetts, which Agassiz used in 1873 as the headquarters of his zoology summer school, became the forerunner of a multitude of summer field camps in the United States, one of the foremost being the nearby marine laboratory at Wood's Hole which was established in 1880.

Amother contemporary American who practiced the field trip technique was educational reformer Francis Parker. Students came from miles around to attend his Cook County (Illinois) Normal School between 1883 and 1899, waxed enthusiastic at the experience of outdoor combined with indoor learning.

By the early part of the present century, the field trip, or field journey as it is termed in Europe, was recognized in England as an official teaching device. In 1908 the city of London actually began to provide subsidies to carry out the local school journeys, and a British School Journey Association was organized which annually publishes a valuable "School Journey Record."

The more recent history of the field trip as a teaching device in educational institutions is sufficiently commonplace to justify lack of comment, except to say that despite criticism from the classical

lecture-laboratory-textbook educators the field excursion has assumed a valued and international place in science teaching.

The expanding role of field trips in adult education since World War I is worthy of more than passing note. The introduction of the layman to natural science in the out-of-doors has nowhere been more successfully accomplished than in our national parks with their free naturalist guide service.

The establishment of the Yellowstone area in 1872 as a national park started a movement throughout the world and especially in the United States towards setting aside natural wilderness and historical areas as inviolate preserves for the eternal benefit and use of the people.

The "use" phase of the national park idea was readily achieved. Twelve thousand tourists made the arduous horseback trip into Yosemite Valley in the California Sierras before the first road was even completed (Russell, 1947). But national park administrators and visitors early recognized that not as much benefit was being derived from the natural features in the parks as possible. It was not sufficient merely to see a geyser in action or an ecological lake succession. There must be some interpretor or teacher to guide the understanding and appreciation of the observer.

Before the first World War universities like Chicago, Harvard, and Columbia did send field classes to some of the national parks. Of more significance was the California Fish and Game Commission's action in 1918 when it loaned Dr. Harold C. Bryant, its educational director, to Yosemite National Park for a number of scientific lectures and experimental field trips for the visitors there. So successful were the results that in 1920 Dr. Bryant was joined in his Yosemite field interpretation by Dr. L. H. Miller; Milton A. Skinner was oppointed park naturalist at Yellowstone National Park; and in the following year, with the cooperation of the California Fish and Game Commission and the University of California, Yosemite National Park instituted the free nature guide service, which eventually spread into national, state, and local parks throughout the country. Today, during the summer season trained scientists who spend their winters in college or secondary school teaching acquaint thousands of citizens with natural science in the laboratory of the out-of-doors.[2]

When Should the Field Trip Be Used?

With this brief historical background, we now turn our attention to an examination of the field trip in its role as an audio-visual teaching device. Obviously, all subject material will not fit into a field

[2] In August of 1949, for instance, a total of 2,460 persons participated in the ranger naturalist field trip program in Yosemite National Park.

trip pattern. Even in the natural sciences there are basic fundamentals which can be derived only from classroom, laboratory, or textbook study. Some classes which would benefit by field work contain such a large group of individuals that the desired excursion is numerically impossible. Quite often the institution in which a potential field course is taught is so located that field work is impractical. Some students may not fit into a field activity. There may be local opposition to field excursions either traditionally[3] or, as in the case of many of our contemporary institutions, because of lack of available transportation and equipment. Are the benefits to be derived from field work commensurate with the extra work and expense? Can the material be more effectively handled by means of other devices? These are but a few of the many considerations which arise as one evaluates the field trip, problems which generally must be solved on the basis of local conditions.

Walter (1950) writes that the field trip provides "opportunities for introducing a unit of work, teaching a concept, or summarizing material studied in a given unit." This broad answer to the question "When?" may serve as a helpful guide. Curtis (1944) warns that we should not expect too much of the field trip by itself. His analytical studies indicated that the excursion contributes most to understanding of the subject when it is employed as a "summary technique."

What Are the Advantages of the Field Trip?

The consensus of opinion among writers on the subject is that the field trip, when handled correctly, is definitely an advantageous teaching device. "The educational theory underlying the field trip is that you discover what something means by responding actively to it" (Dale, 1950).

The advantages are manifold. The student is actually able to see what he has studied. Problems can be solved and knowledge gained away from the textbook. The field trip affords students the opportunity to exercise resourcefulness and self-discipline. The spirit of adventurous research replaces the often boresome classroom routine. The field trip injects variety into a teaching schedule. Learning becomes a cooperative rather than an autocratic arrangement. Observation of the real things creates more lasting impressions than visualization of classroom symbols. In Rousseau's words, "Never substitute the symbol for the thing signified, unless it is impossible to show the thing itself. . . ."

[3] A Montana high school biology teacher told the author that his school board absolutely refused to permit the use of field trips. The teacher conducted such trips as he deemed necessary on an extra-curricular, out-of-school basis. "I'll be standing on the corner on Saturday morning with some nets and collecting bottles," this man would tell his students, "and if you happen along, we might go out in the field." The unauthorized field trips were unusually well attended!

The informal atmosphere of the field trip facilitates a friendly acquaintanceship among members of the group. During later classroom discussions of the field work individuals from such a group feel less timidity or reluctance at participating in the group discussion. The informal field atmosphere also creates a better relationship between student and teacher which can be effectively capitalized upon. Actual observation of some phenomenon in the field usually awakens a strong natural desire in a student to study the subject more fully through later reading and discussion. For the general science or general education student, the field excursion affords an excellent medium for integrating the various divergent subjects of study. This integration is equally valuable in specialized fields. John Heywood's "Better one byrde in hand than ten in the wood" can be reversed to advantage in natural science teaching. There is a limit to what a student can learn from a dead bird.

An evaluation questionnaire prepared by E. N. Stevenson (1940) indicated that when field trips were well organized, they proved to be the most valuable, enjoyable and worthwhile portions of a course of study. F. M. Schellhammer (1935) concluded, after examining two groups of students, one of which had received botanical subject material through classroom lecture, the other through a field trip of the same length and subject content, that the group receiving the field trip instruction, on the basis of their superior test performance, had learned more.

Walter (1950) effectively sums up the advantages of the field trip in the following words:

> "The field trip summarizes old concepts, and by their use in actual situations, teaches new concepts and the power of observation and thinking, and develops new areas of activity and interest for the (students), making their school life real, vital, and above all, interesting."

Planning for the Field Trip

Any teaching, to be most effective, must involve considerable planning and organization. This is especially true with the field trip. Poorly organized lectures can be slept through; poorly organized field trips not only dull the students' interest but can actually become dangerous physical hazards!

Field trip planning, of necessity, must consider a variety of problems. There are numerous suggestions in the literature on what to consider while planning a field excursion (Dale, 1950; Dent, 1937; McKown and Roberts, 1949; Hoban, *et. al.*, 1937; Lobeck, 1947; Walter, 1950; Maddux, 1950; and others). The trip organization broadly falls into three categories: objectives, transportation, and equipment, the first of which, of course, affects the other two.

Dertermination of the trip objectives will be based upon the type

of subject considered, the background of the students, the complexity of the material, and so on. In objective planning, a preliminary field trip by the instructor is absolutely necessary.[4] During this trip the best area for a particular subject of study should be selected and carefully analyzed, teaching possibilities noted, any arrangements for trespassing or local guiding made, hazards anticipated, and the like Quite often, the success of the class trip will be directly proportional to the extent of the preliminary survey. It is preferable that even areas used in the past be revisited before each excursion. Changes such as gravel operations in river bottom areas, poisoning in a prairie dog colony, and so on may have made an area no longer suitable for the particular feature desired. Several authors (Adams, 1942; Clark, 1932; and others) recommend that selected students be included in the preliminary trip, especially when dealing with large classes, so that these individuals can act as group leaders for the class as a whole. Associated with the selection of a field area should be a review by the instructor and perhaps even by the students of literature concerning the phenomena to be seen.

A desirable date for the trip should be selected and perhaps an alternative date. This date selection may seem merely routine. Actually, serious thought must often be given to the selection of the date which will provide the most adequate coverage of the subject material. It would be a waste of time to schedule a field assignment on local amphibians at the beginning of a spring quarter before the animals had come out of hibernation.

Transportation is always a difficult problem in field work. The length of trip, size of class, and anticipated weather conditions play an important role in determining the type of transportation necessary. For large classes where money is available, a chartered bus is the best solution. Individual or fleets of institutional cars or station wagons can be used, open trucks for short trips in good weather, or even private cars. Sometimes trains, planes, and other public conveyances can be utilized, finances permitting. Transportation arrangements should be made well in advance, then rechecked shortly before the trip. For large groups, a roster of students should be prepared and entrusted to the hands of an individual made responsible for the members of the class. It is easier than one might suspect to conclude a field excursion, even with a small group, make the return trip home, and only then discover that a student had been left

[4] The importance of being familiar with the ground cannot be overemphasized. In this respect, the writer is reminded of a ranger naturalist some years ago who conducted a group of tourists to a lake which he had never before visited. From the lake the guide led the people back the way they had come for a mile, then up a very muddy trail to another lake. The naturalist's prestige as a guide diminished considerably when a member of the party discovered that the second lake lay only one low ridgetop away from the first lake.

behind. The teacher should keep in mind that the satisfactory nature of the transportation will reflect itself in the attitude of the students upon arrival at the destination. People who have ridden thirty-five miles over rough roads in an open truck during bad weather are not going to be in a receptive mood for learning anything.

Advanced planning for field and personal equipment is an equally important job. The field equipment, of course, will vary with the objectives of the trip. It is better, however, to carry too much rather than too little equipment. A check list of equipment used for each assignment would prove valuable and timesaving. Collecting and preservation supplies, writing materials, field manual references, and first aid kits are but a few of the items to be considered in planning the equipment of a trip. For long trips there must be planning for food, cooking utensils, bedrolls, and so on. Again the check list is valuable, not only for the teacher but as something to be passed on to each participating student. Included on such a check list should be recommendations for personal equipment, like sweaters, boots, toilet articles, binoculars, notebooks, hand lenses, flashlights, etc.

An important piece of "equipment" provided the students by the teacher may be a written field trip outline, briefly describing the objectives of the trip, the time schedule, precautions, field work to be accomplished, type of oral or written summary desired, and literature references. There are a number of commercial field manuals already in existence in the natural sciences which may be worked into the subject material of a particular course (Park, *et al.*, 1939; Comstock, 1929; Brown, 1948; Hillcourt, 1950; Pettingill, 1947; Needham and Needham, 1938; and others). Personally, this author feels that a field syllabus prepared by the instructor and directed specifically towards the area to be examined will prove of much greater value than a general published manual.

In planning for a field trip, it is almost as important to consider the preparation of the student as that of the instructor. The amount and kind of briefing which students receive before a trip may well have an important bearing on the successful outcome of the excursion. The trip should arise as an outgrowth or introduction to some classroom work and this relationship should be brought to the students' attention. They should have some idea ahead of time of the trip's specific objectives and procedures. When applicable, they should be assigned reference reading which would prepare them for the particular field problem. Several authors who have dealt with the field trip in secondary schools (Walter, 1950; Maddux, 1950; Pitluga, 1947; etc.) recommend that students actually join the instructor in planning and organizing the proposed field trip. The more interested, informed, and oriented a student is prior to a field trip, the better a

participant he will be and the greater chance there is of his deriving lasting educational benefit.

Execution of the Field Trip

The actual teaching devices which can be brought into play during the course of the field trip would—and have—required pages of description. Headlee and Jones (1951), Chick (1948), Walter (1950), Force (1936), and Dexter (1943) all present excellent discussions of field methods. There are numerous general recommendations which will make any field trip more successful.

Although a definite field problem may have been set up, the teacher should emphasize that observations should not be narrowed exclusively to the single problem, nor should they be carried out only within the limited confines of the field area. Too often the time devoted to moving the students from school to destination and back is wasted. Much knowledge can be integrated by observations made from a bus window (Ramaley, 1927).

Lecturing in the field should be kept to a minimum. If the students have had good advanced preparation for the trip and have a working field syllabus, their dependence upon the instructor should mainly be for direction rather than for description. In ranger naturalist guiding, the answer to the question of "What is this?" will usually be "What do you think it is? Have you ever seen anything similar to it? What is it composed of? What was it associated with?" And so on. In other words, and this is a point of agreement among most writers on the subject, the responsibility for acquisition of knowledge is shifted from the instructor to the student. The student in the field has at his finger-tips the answers to many of his own questions! If the field trip occupies a long period of time in one locality or moves from place to place, then the instructor should take the occasional opportunity of calling the students together and briefly discussing or summarizing the findings.

One of the most effective means of making field work valuable is to assign specific research problems to an individual or a group of students. What kinds of ducks are found in the particular lake under observation? How many square inches of bark have porcupines destroyed on a hillside of ponderosa pine? How many animals make use of an isolated cottonwood tree during a twelve-hour period and what is the nature of the use? What is the oxygen content of a stagnant lake or the water discharge from a sewage disposal plant? And so forth. The instructor—if prepared—could probably give erudite lectures on all of the subjects involved. But when the sky is blue overhead and listening minds are wandering, the students would probably slight information which, if gathered by their own endeavor, might

be retained. Problems assigned should be reasonable, interesting, and productive.

The number of people constituting a field trip, the number of concepts which should be introduced, and the length of the field trip are a few of the considerations confronting the instructor. Clark (1932) writes that six or seven people make up an ideal field unit; Harlow (1946) recommends no more than fifteen. Undoubtedly, the smaller the group, the more effective the teaching. When more than half-a-dozen students are involved in a discussion with the instructor, it is advisable for the students to seat themselves around the instructor. Large groups can and have been handled successfully by creating smaller units under the direction of students who were already briefed in the work at hand (Clark, 1932).

The number of ideas which can be successfully covered in a single field trip will vary, of course, with the capacity and background of the students. To a certain extent, the same can be said for the length of the trip. Students who have done previous field research are much less liable to tire or lose interest than people on their first excursion. In national park work and in field zoology teaching, this author has found that the half-day trip (including transportation time) is the most effective teaching unit. If the students have been given insufficient briefing on the objectives of the trip, have an insufficient or indefinite amount of work to accomplish, or detect a disorganization in the particular excursion, they sketchily accomplish the job at hand and restlessly await the return home. This situation should reiterate the importance of organization and suggest that the amount of time in the field should be proportionate to the nature of the task.

Obviously, the importance of taking complete field notes should be stressed. No observation, however insignificant it might seem at the moment, should be omitted. The students should be urged to experiment with various methods of recording data, in order to find the most effective method for each type of problem. When a group of students is working on a single problem, it is often useful to assign one as recorder for the group.

When field trips involve walking, the pace should be set for the slowest person in the group. During rest pauses, the instructor has an opportunity to comment on the things seen en route, answer questions for or draw out ideas from the students. Bad weather during a field trip is usually difficult to turn to good advantage. In certain types of courses, however, particularly those in the zoological field, bad weather may upset original observations but provide opportunity for a study of reaction of animals to inclement weather conditions, etc. In other words, during field work, the good instructor is ever alert to take the best advantage of every factor confronting him.

It has already been mentioned that some courses do not fit into a field study. Likewise, there are probably some instructors who do not, or at least feel that they do not, fit into a field study. There certainly are added problems of discipline, innumerable phenomena requiring an explanation, and similar matters which put a strain on any instructor. Writers on field trip instruction agree that a good field trip requires a good instructor. They also agree, however, that no one expects an instructor in the field to know all of the answers. The teacher who takes the question to which he has no adequate answer and throws it open to group discussion is probably doing more effective teaching than the well-versed instructor who rolls a glib answer off his tongue and passes on to other things. Regarding discipline, if the field work is well organized, the students have been well briefed and are interested, and the instructor is sufficiently informal in his presentation, there seldom will be a discipline problem.

This discussion purports to be no exhaustive discourse on the actual mechanics of running a field trip but does attempt to touch upon certain important phases of the device. At the risk of repetition, it should be reiterated that almost without exception educators feel that the role of the instructor in field work should be that of director rather than lecturer. The instructor's own enthusiasm and interest, his ability successfully to bring the student in contact with subject material in the field, his correlation and integration of the work for the student, his organization of the content and routine of a field trip are the factors which will eventually determine the importance of that field work to the student's comprehension and knowledge of a particular subject.

The Field Trip in Retrospect

The import of the field work should by no means lapse with the return to the classroom. Almost without exception, the major articles on field trip techniques emphasize that the follow-up is as important as the preparation and observation. An effective follow-up may consist of a number of different devices, varying with the course and instructor. Individual or group written reports help to clarify the field data in the minds of the students and preserve them for future reference. The group discussion logically follows field observations, especially if the different individuals have carried out different portions of the field work. In the class discussion the main threads of the pertinent subject can be drawn out of the amassed observations and tied into a vitalized summary and composite picture for and by the students and teacher. At all opportune moments during the course of the discussion, the instructor should take the opportunity of relating the field observations to the lecture and laboratory presentation of the

same material. Prepared maps, graphs, charts, lists, photographs, kodachrome slides, and other visual aids can be based upon the field work and presented as evidence in the group discussion. After the discussion period, while interest in the subject is still high, the instructor should make available pertinent literature references which the students can peruse for a more comprehensive understanding of the phenomena under consideration.

As a final obligation in the use of the field trip technique, the instructor should attempt to evaluate each of his field trips in terms of its success and value to the course work, paying particular attention to the assignment's fulfillment of the original field trip objectives. There are innumerable methods of evaluation, two of the best being those by McKown and Roberts (1949) and Deyoe (1947).

In concluding this discussion of the field trip as a science teaching technique, it seems appropriate to quote from a cleverly sarcastic speech delivered some years ago to the American Society of Naturalists by its retiring president, scientist and educator Dr. William Morton Wheeler (1923). Heads in the audience must have nodded wearily as Dr. Wheeler facetiously painted the scene so familiar to us at the beginning of each school year. . . .

". . . Every autumn we lay in a few cans of soused dogfish and pickled sea-cucumbers, coop up some guinea-pigs, earth-worms, cockroaches and fruit-flies, throw in a bag of beans and several bales of hay for the botanists—and we are prepared for the worst."

It is encouraging that we biology teachers and our students are now being prepared "for the better" by putting into practice one of Professor Wheeler's subsequent exhortations:

". . . And—although I realize the great difficulties involved—some means must be devised for taking the student into the field more frequently, since it is impossible to reproduce and study the more complex biocoenoses under artificial conditions."

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A DIRECTORY OF 2002 16 MM. FILM LIBRARIES*

SEERLEY REID AND ANITA CARPENTER

This directory is a State-by-State and city-by-city list of sources from which 16 mm. films can be borrowed or rented It includes libraries which handle entertainment films and those which handle instructional films. Listed are libraries which have only one film and libraries which have thousands of films. The directory includes also commercial dealers, colleges and universities, city and State school systems, public libraries, industrial companies and trade associations, labor unions, civic groups, religious institutions, and Government agencies.

A Directory of 2002 16 mm. Film Libraries will be helpful to teachers, school administrators, librarians, community leaders, and others who use or may wish to use motion pictures in their educational and informational programs.

* Office of Education Bulletin 1951, No. 11. 113 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 30 cents.

FROG AND TURTLE REMNANTS OF DRIER MIDWEST LONG AGO

The Midwest was much drier 10,000 years ago than it is now. That is the conclusion of Dr. Philip W. Smith of the Illinois Natural History Survey from a study of new species of mud turtles and of chorus frogs of western Illinois' sand prairies.

Both these animals have now been found for the first time three to four hundred miles farther east than usual. Dr. Smith considers them survivors of a time when western Illinois was a prairie peninsula. Since both the turtle and the frog are subspecies of animals found on the Great Plains, Dr. Smith believes that the present specimens are remnants of subspecies that were formerly widespread. Dr. Smith reports in the Bulletin of the Chicago Academy of Sciences that the frog has been named Pseudacris streckeri illinoensis and the turtle, Kinosternon flavescens spooneri.

THE USE OF LABORATORY ACTIVITIES IN TEACHING GENERAL SCIENCE*

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"To be or not to be" is no longer the question when we are discussing laboratory work in the teaching of general science.

Despite the research carried on concerning this problem, experience has compelled us to utilize laboratory work in the teaching of science. When our objectives were interpreted as the ability to recite facts the laboratory had little function.

Today we think of the results of science teaching in broader more functional terms. Our objectives include such concepts as understandings, attitudes, skills, interests, and appreciations. These outcomes are to have meaning to the individual and possess some social significance. If we are to realize these objectives the pupils must learn science rather than learn about science. Pupils can learn about science through reading and listening without utilizing the laboratory. If we are to help pupils learn science we must utilize reading, listening and laboratory experiences in the solution of meaningful problems. There is no attempt being made to discount the effective use of other materials in the teaching of science. This discussion is concerned primarily with the function of the laboratory in teaching general science.

The laboratory must not be defined as a room in a building, but rather, must include the great out of doors and the community as well as the well equipped laboratory in the school. Many times the school yard, the furnace room, the fish hatchery, the zoo or the local power plant are the best laboratories we have.

Laboratory activities are often defined to include demonstrations as well as individual or group activities. In this discussion laboratory activities are to be considered as individual or small group activities carried on by pupils. The teacher is to serve as the guide or helper of pupils.

What function may be attributed to the laboratory in general science?

These may be stated generally as:

1. A means of securing information.
2. A means of determining cause and effect.
3. A means of verifying certain facts or phenomena.
4. A means of applying what is known.
5. A means of providing drill.

* Presented at the General Science Section of the Central Association of Science and Mathematics Teachers at Cleveland, November 23, 1951.

6. A means of carrying on individual research projects.

Each of these functions is important depending upon the type of activity or nature of the material covered.

These six functions are to be discussed separately.

1. A Means of Securing Information

Some of the topics to which this may contribute are: products of combustion, the effect of heat upon gases, liquids and solids, Archimedes' principle, magnetism, images in mirrors, structure of plants and animals, habitats of plants and animals.

When the laboratory is to serve as a means of securing information specific plans must be made so that this will be accomplished. This may demand a good deal of teacher time. The plans or instructions for carrying out the activity may be teacher planned or cooperatively planned by pupils and teacher. If they are teacher planned the pupils must know the purpose of the activity and have some guidance in performing the experiment and making observations. The guides, whether teacher planned or cooperatively planned, must not tell the pupil what he is to see. They may tell him what to do in setting up and manipulating apparatus, but not what he is to see. The guides may contain instructions which will aid him in seeing relationships.

An example is given to illustrate this point.

Problem: Some objects float in water and some objects sink in water. What forces act on these bodies?

Materials provided by the teacher: overflow can, balance, weights, graduate, beakers, regular block of wood, regular block heavier than water.

Instructions: Place a beaker under the spout of an overflow can. Fill the can so that some water will flow out of the spout. Empty the beaker after the excess water has run out and replace it under the spout.

1. Weigh the block of wood _____ gms.
2. Measure the block of wood. L_____W_____H_____.
3. Volume of the block L×W×H=_____cc.

Carefully place the block of wood in the water in the can (do not allow it to splash). Notice that some water will run out of the spout of the can. Allow the beaker to remain under the spout until the water stops dripping.

4. Weigh the graduate. Weight empty_____ gms. Pour the water from the beaker into the graduate.
5. Weigh the graduate with the water in it. _____ gms.
6. Weight of the water in the graduate. _____ gms.
7. Volume of the water in the graduate. _____ cc.
8. Does the wooden block float or sink? _____.

9. How hard does the block push down on the water? _____ gms.
10. How hard does the water push upon the block _____ _____ gms.
11. Compare the volume of the block with the volume of the water that ran out when the block was placed in the can. _____
12. Compare the weight of the block with the weight of the water that ran out of the can. _____.

(Repeat this experiment five times and average the results)

Conclusion: A body that floats displaces its own _____ when placed in water.

(Repeat the above steps but this time use the heavy block)

13. Weigh the heavy block _____ gms.
14. Measure the heavy block L_____W_____H_____.
15. Volume of the heavy block L×W×H=_____ cc.
16. Weigh the empty graduate_____ gms.
17. Weight of the graduate with water in it _____ gms.
18. Weight of the water in the graduate _____ gms.
19. Volume of the water in the graduate _____ c.c.
20. Does the heavy block float or sink? _____.
21. Compare the volume of the block with the volume of the water that ran out when the heavy block was placed in the can. _____.
22. Compare the weight of the heavy block with the weight of the water that ran out of the can._____.

(Repeat this experiment five times and average the results)

Conclusion: A body that sinks displaces its own _____ when placed in water.

Through a discussion of these data with the pupils the question is partially answered. The teacher then aids the pupils in discovering that there is an upward force acting on the body that sinks by utilizing more laboratory work. The pupils may now participate in some other type of activity as reading, etc.

2. A Means of Determining Cause and Effect

Some of the topics effectively developed through this type of laboratory activity are: factors affecting the pressure in liquids, factors affecting the rate of flow of a siphon, factors affecting the period of the pendulum, factors affecting the rate of vibration of air columns, factors affecting the rate of vibration of strings, factors affecting the process of osmosis, factors affecting the growth of plants.

When the laboratory is to serve as a means of helping pupils determine cause and effect relationships it calls for careful cooperative planning by pupils and teacher.

An example to illustrate this point.

A class may be studying the siphon. The problem arises, "How can the siphon be made to flow faster or slower?" The teacher and the pupils would list such factors as: the size of the tube, the shape of the tube, the material of the tube, the difference in levels of the liquids, the nature of the liquid used, etc.

Through cooperative planning the class would develop controlled experiments to test each factor. Groups would select the factor they wished to test. It is obvious that all pupils would not do the same thing at the same time.

Following the experimentation the class would pool its data and formulate conclusions.

3. As a Means of Verifying Certain Facts or Phenomena

Securing information and determining cause and effect have been examples of the inductive method. The verification of facts or phenomena is an example of the deductive method.

Some topics to which this method may be effectively applied are: generation of oxygen using mercuric oxide, freezing and boiling points on thermometer scales, relative humidity, storm paths, fossils, soap making, plumbing systems, longitude, and latitude, and bacteria.

Example: A class may be working on the problem of the measurement of temperature and has discovered that some thermometers have different scales on them. They wish to check the freezing and boiling temperatures on each of these thermometers so they go to the laboratory. Here they immerse both the Fahrenheit and Centigrade thermometers in melting ice and later in boiling water. They are verifying the existing scales.

The class may be studying fossils so each member is provided with some fossil form so that he may observe them and feel of them.

4. A Means of Applying What Is Known

This is a time when both the inductive and deductive methods apply in teaching science.

Some topics to which this contributes are: the effectiveness of various kinds of insulation, water softening, submarine, airplane, photography, music, insect control, diets, growing plants, determining the age of trees, classification of rocks, and compound machines.

Example: A problem concerning the effectiveness of insulation of various types may come up in the class. The class can set up an effective method of testing the types. In the planning of the apparatus to be used the pupils use what they know. Several boxes of the same size may be constructed. The walls of each box will be lined with a different kind of insulating material. Thermometers are placed inside the boxes and the boxes placed in both cold and hot surroundings for

given periods and the temperature readings made periodically.

The most effective insulation is the one in that box showing the smallest change in temperature from the normal in each case of heat and cold.

5. A Means of Providing Drill

This, is, all too often, the only function of the laboratory we find utilized in teaching science. Very often when the laboratory should be used as an inductive tool, it is used as a deductive tool or becomes drill.

When the laboratory is to be used as a drill technique the activity is teacher planned. Some topics to which this techniqe may be effectively applied are: the use of the microscope, measurement, tests for protein, sugar, carbon dioxide, etc., simple circuits, reading instruments, and other laboratory techniques.

6. A Means of Carrying On Individual Research

Some teachers enjoy a good deal of success in helping pupils to learn through the use of projects. The development of these projects by the pupils is a form of research and many times demands the utilization of the laboratory. In project teaching the laboratory phase involves all five of the previously noted functions, i.e., securing information, cause and effect, verification, application and drill.

The research carried on by pupils need not lead to the discovery of something new "under the sun," but rather, it should lead to something new for the pupil. This something new for the pupil may be that he is unable to find an answer. Scientists do not always find answers, let alone the correct answers, so we have no right to always demand the right answers from the pupils.

Generally, the laboratory is a place to seek and to find information and relationships. There are times when it is used as a place to prove and to drill, but this is not a primary function of the laboratory in the teaching of general science.

In science we are attempting to answer "What," "How" and "Why" questions. The laboratory is the place where "What" and "How" questions are answered. Unfortunately we are unable to observe "Why" things happen. Care must be exercised in the use of the laboratory not to ask pupils "Why" something happened. Why did the wooden object float in water and the iron object sink? Why did the seed sprout? Why did the leaves turn toward the light? Why does water flow from a high level to a lower level? These questions can neither be answered by the pupils nor the teacher. These questions are philosophic in nature and are not demonstrable.

After pupils have gathered data in the laboratory concerning what

happened or what exists or how something happened they are in a position to formulate conclusions. These conclusions should usually be stated in the pupils own words. The statements may not be as polished as those the teacher may formulate, but they will express what the pupil learned.

Laboratory work for pupils in general science is psychologically sound if we believe that we learn by doing, if we believe that we should go from the concrete to the abstract, if we believe that we should go from the known to the unknown. The laboratory is the place where pupils gain first hand experience with things and phenomena. They receive stimuli through seeing, feeling, smelling, hearing, and sometimes tasting. The pupils gather data and draw conclusions. They learn the value of data and its limitations. The pupils learn to think by thinking; they learn to solve problems by solving problems; they learn to draw conclusions by drawing conclusions; they learn to apply knowledge by applying knowledge in real situations.

Laboratory work all too often has been a course aside from the rest of the science course. It has been compared to two trains on separate tracks each going its separate direction and rate. Rather, the laboratory is to be compared to two trains on parallel tracks joined by common axles. The laboratory is a part of the science course.

Removing the laboratory and the experimental aspects from science is destroying its peculiar educational function and its distinctive feature. Laboratory work properly considered is first hand study of things and phenomena. It must have its conception in problems and lead the pupils to do some thinking and lead to more problems and more laboratory work.

Laboratory work cannot be an integral part of the science course if laboratory periods are scheduled for certain days of the week. This happens when double periods are provided on specific days. A teacher must have some degree of flexibility in planning his course work. Double periods for laboratory work in general science are no longer educationally defensible. If the class periods are approximately one hour in length, the pupils have ample time to complete most laboratory activites. When field trips are to be taken arrangements can usually be made with administrators and other teachers to take care of the needed time.

Laboratory work cannot be an integral part of the science course if the rotation plan of laboratory experiments is followed. The laboratory exercise is to be used when it is the most effective method of helping pupils to learn and not when it happens to fit into a given administrative pattern.

When enough laboratory exercises are carried out by pupils they are mentally equipped for the more rapid interpretation and solution

of problems through the utilization of scientific facts and principles. They are better equipped to assimilate and interpret the printed page. If the attention of pupils has been centered on a topic or problem and their interest aroused by laboratory contact with certain phases of the problem, it may be expected to some degree at least, that there has been developed a desire for further knowledge.

Any science course shorn of its laboratory phase is scarcely worthy of the name science.

A MODEL OF THE FIVE REGULAR POLYHEDRA

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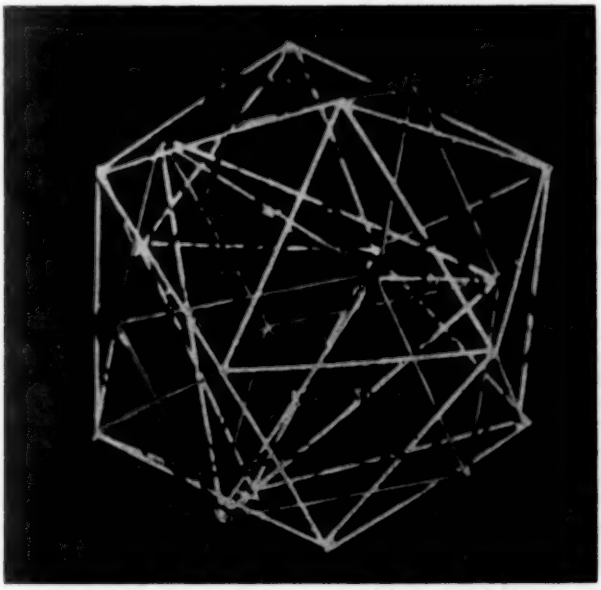
It is common practice for students of Solid Geometry to build separate models of the five regular polyhedra. After they have done this, it may be desirable for them to make a single model of all five of these figures and thus to learn something of the inter-relationship of the parts of the Platonic Solids.



It is well known that the five regular polyhedra have a spacial duality. That is, if for any of the regular polyhedra the number of vertices and faces are interchanged while the number of edges is kept constant, the resulting set of three numbers characterizes another (or the same) regular polyhedron. Another way of looking at this is to consider the figure formed by joining the midpoints of adjacent

faces of any such solid. The result will be to outline a regular polyhedron. In this sense, the cube and octohedron, as well as the dodecahedron and icosahedron, are dual pairs. The tetrahedron is self dual.

It is also of some interest that the number of edges of the tetrahedron and cube correspond respectively to the number of faces of the cube and dodecahedron.

These relationships may be exploited to build a stick model of these polyhedra about a common center. The cube is made first with as much care as possible for any errors made in its construction will be magnified in the construction of some of the other solids. By placing a diagonal in each of the six faces of the cube, a tetrahedron is formed. The octohedron is made by joining the midpoints of adjacent edges of the tetrahedron. The dodecahedron is then constructed about the cube with each edge of the cube forming one of the diagonals of a face of the dodecahedron. Finally, the edges of the icosahedron are placed as perpendicular bisectors of the edges of the dodecahedron.

The edges of the five solids should be painted five different colors to provide contrast and to make it easier to distinguish the separate figures.

A NEW FILM "MORNING STAR"

A contract for the exclusive distribution by Encyclopaedia Britannica Films of the full-color motion picture SHEEP, STARS AND SOLITUDE has been signed by Walter Colmes, president of EBFilms, and Francis R. Line, producer of this motion picture and a prominent film-lecturer, it has been announced.

Colmes said the film, which formerly had a running time of an hour and a half, will be edited to a running time of 35 minutes to adapt it for educational use. The shorter version of the film will be called MORNING STAR.

The film, in both versions, tells the story in color and sound of the spring migration of a herd of sheep across the wildest, most inaccessible area remaining in the United States—the Tonto Basin near Phoenix, Arizona. Led by a veteran shepherd, the sheep travel over the rugged desert land through all kinds of weather until they reach the mountain pasture lands. Because of the patience and skill of the shepherd not a single sheep was lost during this long trek which took 52 days and nights. Aspects of typical plant and animal life are seen throughout the film.

SHEEP, STARS AND SOLITUDE has been acclaimed by educators throughout the country for its "poetic qualities" and "moving symbolism." Line has used the film as a basis for film-lectures in many parts of the country. He is the producer of a number of other motion pictures on phases of American and foreign life and folk lore.

Duplicating machine makes exact copies of letters and other papers by a dry-process method utilizing infra-red light. An infra-red light source sends rays through a special heat-sensitive sheet to the black-and-white orginal copy. The black type face converts the rays into heat which acts upon the heat-sensitive sheet.

A BOTANIST IN THE ANDES*

HARRY J. FULLER
University of Illinois, Urbana, Ill.

The Andean region of South America is one of the most fascinating areas of the New World for study by botanists, zoologists, geologists, geographers, anthropologists, and other scientific workers. A region of massive mountain ranges and of peaks, many of which, rising to elevations of over 20,000 feet, are eternally capped by ice and snow, it presents landscapes of incomparable majesty and impressive ruggedness. Botanically the Andean area is rich, for it includes many types of vegetation, among them desert, grassland, deciduous forests, tundra, and tropical rain forest, and it is the native home of a number of economically valuable plants, including the tomato, Irish potato, sweet potato, coca (source of cocaine), quinine, certain varieties of corn and beans, and quinoa, a starch grain-like product of a plant closely related to our weedy lamb's-quarters. Although in some areas, modern, mechanized methods are employed in agriculture, the greater portion of Andean farming is carried out by hand methods which have changed but little since pre-Spanish times. The persistence of these laborious farming methods is attributable to many factors: the small size of many agricultural holdings, the general proverty of Andean farmers, and their reluctance to break with the traditional practices of plant cultivation. Further, the mountainous nature of many agricultural areas of Peru and Bolivia, with but few level fields suitable for mechanized farming, will probably always be a limiting factor in the development of modern agricultural methods. The Incas at an early data found it necessary to construct agricultural terraces on steep mountain slopes in order to produce enough foodstuffs for their survival, and in present-day Peru and Bolivia, such terraces are still in extensive use, many of them dating back to pre-Spanish days, others constructed more recently but still in the traditional Inca pattern.

The dried leaves of the coca plant are chewed by a large segment of the Andean population, and the trade in coca leaves in public markets is brisk. Coca leaves, because of the cocaine which they contain, have a narcotic effect upon those who chew them; coca users develop remarkable resistance to cold and fatigue and are able to withstand prolonged physical strain without apparent weariness. Unlike opium and marihuana, coca does not lead to immorality or crazed and irresponsible excesses. Whether or not the coca habit leads to a deteri-

* Illustrated with colored movies and delivered before the Biology Section of the Central Association of Science and Mathematics Teachers at Cleveland.

oration in health and mental powers is still a much debated question.

Among the interesting animals of the Andes are the llama and vicuña, both related to the camels. The llama, a domesticated derivative of the wild guanaco, plays a major role in the lives of Andean peasants. It is the most common beast of burden, it produces an abundance of wool used in spinning and weaving, its flesh is edible, its hide is used for water skins, and its dried dung is a major fuel in many areas above tree line. The vicuña, a wild animal of high mountain fastnesses, is smaller than the llama and is highly prized for its soft, fine wool, which is used in the weaving of fine, delicate fabrics. In some areas of the Andes, the vicuña, approaching extinction is now protected from hunters by governmental decrees.

The people of the Andean upland are largely of Incaic origin, many of them full-blooded, others of mixed Incaic and European stocks. In both Peru and Bolivia, the pure Incas constitute more than half the population, and these, added to those of mixed Inca blood, make up more than four-fifths of the total. Many of these people still speak the Inca dialects of their remote ancestors, in addition to Spanish, and in some of the more remote areas, there are Indians who speak only these ancient languages, who know nothing whatsoever of Spanish. Negroes are few in number, as are the pure-blooded whites, who occupy most of the major positions in government, commerce, and the professions.

Most impressive of the human features of the Andes are the remains of the great Inca civilization which was overthrown by the Spanish in the early 16th century. In many parts of Peru, Inca ruins dot the landscape; these range from fragments of foundations of granaries and watch-tower to cities of many dozens of buildings. The ancient Inca capital, Cuzco, a small city high in the mountains of Peru, is surrounded by ranges in which various Inca ruins are situated; one of these ruins, Sacsahuaman, is that of a large, terraced fortress which dominates the valley of Cuzco and which protected it from enemies in pre-Columbian days. Half a day's journey from Cuzco by *autocarril* (a small bus with railway wheels which runs on tracks) and by mule is the most famous, most extensive, and most thoroughly studied of all Inca ruins, that of Machu Picchu, high on a knife-like ridge two thousand feet above the rushing Urubamba river. Machu Picchu, now a ghost city but once inhabited by thousands of people, includes many types of structures—a solar observatory, religious temples, granaries, barracks for the military, private homes, elaborate agricultural terraces, and others—all beautifully constucted of stone blocks. Many of these blocks were cut with such precision that it is impossible to slip a card or the blade of a penknife between them; placed in position without mortar or cement of any

kind, these blocks still form the walls of the timeless city of Machu Picchu.

Peru and Bolivia, by our standards, are poor countries. At the top of the economic heap is a small group of wealthy familes, and below these is a small middle class of moderate circumstances. But the bulk of the population is beset by poverty and leads scarcely more than a hand-to-mouth existence. Money-making exports are chiefly tin, copper, some petroleum, and guano, the rich fertilizer derived from the dung of birds; most agricultural products are consumed within the countries in which they are grown, so that few such commodities are available for export. Rubber, balsa wood, and tropical hardwoods are shipped out from the Andes from time to time, usually in moderate quantities. What profits are derived from the foreign sales of such modest exports remain chiefly in the hands of the principal families and do little to raise the living standards of the masses.

A GAS FILLS COMPLETELY ITS CONTAINER

JULIUS SUMNER MILLER
Dillard University, New Orleans, Louisiana

This well-known property of a gas, so happily recited by students, is interestingly demonstrated in the following manner:

Blow up by mouth or by pump a toy balloon to a size say, of a large orange. Tie it off tightly and place it under a large bell-jar mounted on a vacuum-pump plate. Exhaust the bell-jar with the vacuum pump. As the exhaustion proceeds the balloon expands and, if it does not burst before, it "fills completely" the enclosing bell-jar. Indeed, the balloon very nicely shapes itself to the enclosing surface.

The demonstration is perhaps more impressive if the balloon is not blow up at all, that is, merely tied off, as the students would proclaim, "*with nothing in it*"!

And the larger the bell-jar the more spectacular the demonstration, provided, of course, you have a good enough balloon.

GIANT PLANET JUPITER NOW HAS TWELVE MOONS

The giant planet Jupiter seems definitely to have 12 moons. The faint object discovered late in September by Dr. Seth B. Nicholson of the Mount Wilson and Palomar Observatories is now believed to be a new satellite.

When first announced, astronomers thought the 19th magnitude object found on plates taken with the 100-inch Hooker telescope might be one of Jupiter's other satellites. Repeated photographs of this new object and a search for the other satellites with which it might be confused, however, indicate it is a new moon.

Jupiter's four large satellites were discovered in 1610 by Galileo Galilei. Now over 340 years later Dr. Nicholson appears to have equalled his record by becoming the second person to have discovered four moons for Jupiter. Sir William Herschel was another famous moon-finder, having spotted two satellites for Uranus in 1787 and two for Saturn in 1789.

THE TEACHING OF COLLEGIATE MATHEMATICS

C. V. NEWSOM
University of the State of New York, Albany, N. Y.

SCHOOL SCIENCE AND MATHEMATICS takes pleasure in presenting the second of its informal articles on the teaching of collegiate mathematics, phrased in the form which might be used by an experienced teacher writing to a young colleague.

This article is by Professor C. V. Newsom. Professor Newsom received his doctorate from the University of Michigan. He has served among other positions as head of the departments of mathematics at the University of New Mexico and at Oberlin. His present connection is with the University of the State of New York; Mr. Newsom is the associate commissioner of education for the State of New York. He is the author of several text books and articles in professional journals. He has served on many committees and commissions dealing with mathematics instruction, and is rated by his colleagues as a master teacher.

CECIL B. READ, *Mathematics Editor*

There is no particular formula that a teacher must follow in order to be successful; rather the classroom method of any individual must be developed as the product of his own experimentation, his personality, and his interests. About the only precept that can be regarded as general is that a person should not try to teach if he does not like teaching; moreover, there is no chance of being a successful teacher unless the person concerned can fill the classroom with his own enthusiasm for his subject. Through the years I have visited many classes on many subjects, and I have observed many different methods of teaching. A particular device that is successful in the hands of one person will fail utterly in the hands of another, so I have ceased giving any major attention to method. On the other hand, the teacher who expresses dread upon entering the classroom will find that same feeling reflected in the students, who sit in anticipation of the end of the hour. The teacher who enters the classroom with dynamic enthusiasm for the topic under discussion will find the students reaching out to participate in the experience. Too many teachers are dull and expressionless; they go through their patter in routine fashion.

I have always insisted that the teacher of mathematics, as with any other subject, must be a creator at the same time that he is a teacher. I have heard frequently that a large number of research men are very poor teachers; that is true. But, I have never known a good teacher who was not simultaneously indulging in some kind of creative work. It is necessary that the teacher stay active as a thinker if the classroom is to be dynamic. I do not mean that every teacher of mathematics must produce a regular number of research papers on some form of abstruse mathematics; some may do so. There are many other opportunities that are attractive and meaningful, such as the writing of expository treatments, the organization of new syllabi

and new approaches to various concepts, the development of a new set of problems, the analysis of the historical background of some subject, or participation in group seminars.

In all honesty I may say that some teachers are dull because they overstudy the lesson for the day, and do not spend enough time upon the fringes of the lesson. I have seen teachers enter the classroom with the entire hour entirely blocked out, and usually such a person can meet the schedule as planned with minimum deviation, for it is not anticipated that there will be any student interruptions. The good teacher has a general idea of where he is going during the hour, but the actual manner of getting there will depend upon many factors that cannot be anticipated. He will enter the class room with an understanding of the origin and evolution of the concepts to be treated; he will understand how the concepts are used in practice and to what extent they form a basis for further study; moreover, he will be filled to overflowing with illustrations of the concepts and all sorts of funny little tangents along which his mind may stray if the appropriate moment arises. As I have said many times, there is no automatic transfer of knowledge from teacher to student; all the teacher can do is to create an atmosphere in which learning can take place. Some of the very best teachers have permitted the main thread of a course to be developed to great extent by the student in his home work, and the classroom has been used for most everything except the main topic under consideration. In other words, when a student possesses enthusiasm and interest, along with certain basic understandings, the systematic development of a subject becomes more or less incidental. Some of this may be heresy, but I believe that it produces genuine scholarship in our students.

The teacher of mathematics has a special concern that is not found in many other subjects. I refer to the moot question of "rigor." It is essential to realize that there is no such thing as absolute rigor; rigor is a relative term; it is relative to the age in which we live and it is relative to the person's mental maturity. Many teachers of mathematics fail miserably becase they make presentations upon a level that involves an utterly different standard of rigor from that which is a part of the student's thinking. I do not mean that the teacher must come down to the level of the student; it is possible with experience to operate upon a level that is slightly in advance of that of the student. The proper diagnosis of this particular problem will make considerable difference in the success of a teacher.

Too many teachers talk too much. The classroom is chiefly for the students. Under proper guidance on the part of the teacher a whole topic can be developed by the class. The teacher may start, and permit himself to get into a very difficult predicament. At that point

many ideas will be offered by students to resolve the difficulty; an analysis of these so-called solutions will mean that many are discarded in favor of others which seem to be promising. By pursuing the promising leads other predicaments will be encountered, and the process is repeated; after all, a whole course in mathematics is that of meeting predicaments and then resolving them in favor of other predicaments. Students can soon get into the spirit of the thing and vie with each other in trying to make suggestions that have merit.

These are only a few of many suggestions that occur to me. They are the result of twenty-five years of experience as a teacher, and I hope they will be of interest to newcomers to the profession.

RIDER'S TV 8—LARGEST TELEVISION MANUAL TO DATE—NOW AVAILABLE

The distributors of John F. Rider Publisher, Inc., 480 Canal St., New York 13, N. Y., have received stock of the largest Rider Television volume yet published by the organization—TELEVISION MANUAL VOLUME 8.

Containing the equivalent of 2,688 ($8\frac{1}{2}\times11$) pages, the new TV service data volume contains approximately 600 models, the productions of 52 manufacturers. The factory-authorized coverage is for the period June through September 1951. All pages in the 12×15 inches volume are systematically prefiled for immediate service bench use. As in previous editions, TV 8 contains a cumulative index for the complete set of eight Rider television volumes.

All manufacturers' production runs and chassis modifications are presented with original and modified schematics. Also included are chassis views, voltages, resistance readings, complete alignment procedures, trouble shooting test patterns, waveforms, complete parts lists and parts values, boosters, tuners, and a special section devoted to manufacturers' changes on earlier production runs. Additional time-saving features are unpacking and installation data and circuit action descriptions. TV 8 is priced at $24.00.

HOT ROCK MAKES STRANGE CIRCLES IN ARCTIC CANADA

Several peculiar circular forms, looking like meteor craters in reverse or rocky boils on the skin of Mother Earth have been discovered on two Canadian islands in the Arctic Ocean.

One on Melville Island is four to four and a half miles in diameter and rises 739 feet above the surrounding flat country. There is another, about eight miles to the east, almost exactly like the first circular form.

Two smaller circular forms and two much larger elliptical forms were found on Ellef Ringnes Island, about 200 miles to the northeast of Melville. All of the forms were discovered in Royal Canadian Air Force photos.

Geologist I. C. Brown, of the Canadian Geological Survey, believes that the large, elliptical forms on Ellef Ringnes Island were formed by hot volcanic rock which could not reach the surface. It could have spread out under the surface, pushing it upward to shape the forms.

The circular forms, he believes, are ring dikes. A dike, to a geologist, is a mass of volcano-formed rock intruded into a fissure of older rock.

Mr. Brown emphasized, in an article in the current issue of the *American Journal of Science*, that the forms had been studied only from photographs and not at first hand.

APPLICATIONS OF ULTRASONIC WAVES IN CHEMISTRY*

ERNEST YEAGER
Ultrasonic Research Laboratory, Western Reserve University, Cleveland, Ohio

INTRODUCTION

As part of the chemist's constant attempt to find new tools for the study of chemical systems, various phases of physics have been applied in chemistry. During the past century optical methods have found extensive use in chemistry in applications ranging from the initiation of chemical reactions with ultraviolet light through the analysis of complex mixtures in terms of absorption measurements. In contrast, only during the past two decades has any serious consideration been given to sound waves as a tool for the chemist. Even today relatively few chemists are aware of the possible uses for acoustical techniques in their field. While it is not likely in the near future that acoustical methods will attain the prominence of optical methods in chemistry, several interesting applications for sound waves have already been developed and a relatively large number are on the horizon.

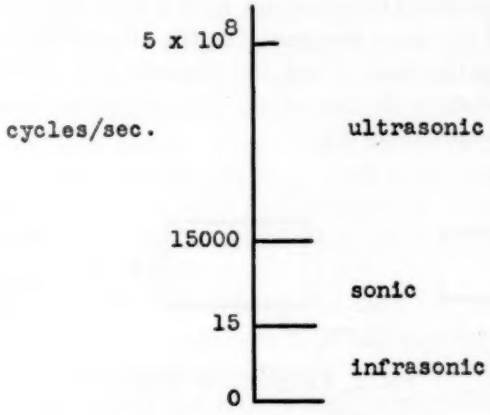


FIG. 1. The acoustical spectrum.

THE ACOUSTICAL SPECTRUM

Sound waves can be divided into three catagories (Figure 1) on the basis of frequency or pitch: infrasonic, sonic, and ultrasonic. This classification is a consequence of the frequency limits of the human ear with the term sonic representing sound waves within the range

* Presented at the convention of the Central Association of Science and Mathematics Teachers, Chemistry Section, in Cleveland on November 23, 1951.

of normal hearing, *i.e.* 15 to 15,000 cycles per second, and the terms infrasonic and ultrasonic[1] referring to sound waves at frequencies below and above the limits of hearing, respectively. In the latter case, sound waves have been produced at frequencies as high as 500 megacycles (500,000,000) per second and it is probable that even higher frequencies will be reached in the near future. While chemical applications have been found for sound waves at frequencies in all three classifications, the majority of the applications involve ultrasonic waves.

The Generation of Ultrasonic Waves

The piezoelectric effect[2] has been used very often as a means for producing ultrasonic waves for chemical purposes. Materials which exhibit this effect can be made to either expand or contract when placed in an electrical field. The situation is represented in Figure 2. A thin film of a metal such as silver or gold is deposited on two opposite parallel surfaces of the piezoelectric material. When one metal surface is charged plus relative to the other, the material will either expand or contract. Reversing the polarity of the potentials on the metal surfaces will produce the reverse mechanical effect. When an alternating potential difference is applied between the two metal surfaces, the material will expand and contract periodically. If any surface of the material is in contact with a fluid such as air or water, sound waves of the same frequency as the alternating potentials will be radiated into the fluid. Thus, the piezoelectric material is equivalent to a transformer or transducer for the conversion of electrical energy into acoustical energy.

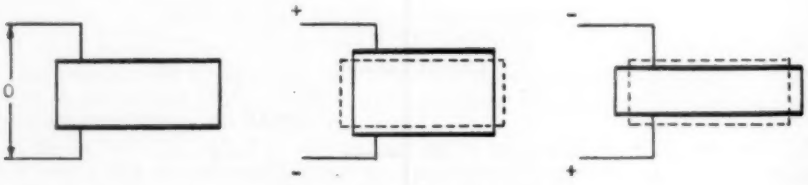


Fig. 2. The piezoelectric effect.

Crystalline quartz as well as barium titanate are used extensively at the present time for the generation of ultrasonic waves. Frequently these materials are prepared in the form of circular disks with the two plane surfaces covered with a thin metallic film. The gas or liquid

[1] Prior to 1946 the term supersonic was widely used for sound waves at frequencies above the limit of the human ear. At the present time, however, the term supersonic is reserved exclusively for phenomena which involve *speeds* greater than that of sound (*e.g.* supersonic flight).

[2] For a more complete discussion of the use of the piezoelectric effect in the generation of ultrasonic waves, the reader is referred to one of the two texts on ultrasonics (1, 5) listed in the references at the end of this paper.

into which the ultrasonic waves are to be propagated is placed in contact with one of the plane surfaces. For very high acoustical intensities, a sound source with a concave surface may be used to focus the sound waves (Figure 3) in much the same fashion that light rays are focused with a concave mirror. Barium titanate is more suitable than quartz for this purpose because of its structural characteristics.

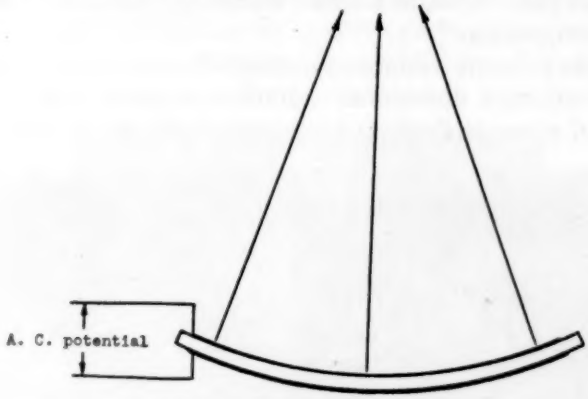


FIG. 3. Focused ultrasonic source.

In Figure 4 is shown an ultrasonic generator constructed at Western Reserve University. The cabinet on the left contains the electronic unit which generates the high frequency electrical energy. In the glass tank or jar on the right is an oil bath in which is mounted a concave barium titanate ultrasonic source with a shape similar to that of a small bowl. The barium titanate transducer converts the electrical energy into acoustical energy. Liquids and solutions to be irradiated with ultrasonic waves are placed in a small glass vessel of the type held by the research assistant in the photograph. This vessel is positioned in the oil bath in such a fashion that the sound waves converge within the liquid inside the vessel.

While the piezoelectric effect has been used for the generation of very intense ultrasonic waves in liquids as well as solids, it is relatively inefficient for the case of gases primarily because of the difficulty in transferring intense sound waves from a vibrating solid to a gas phase. Ultrasonic sirens as well as similar devices have been developed for the generation of intense ultrasonic waves in gases.

THE PHYSICAL PROPERTIES OF INTENSE ULTRASONIC WAVES

Before describing the applications of ultrasonic waves in chemistry, some of the rather unusual properties associated with intense ultrasonic waves will be considered. Of particular interest is the tremendous acceleration associated with the wave motion inherent in the

ultrasonic waves. For the case of sound waves in water at a frequency of one megacycle per second and an acoustical intensity[3] of 1 watt/cm.^{2}, the maximum acceleration experienced by the water molecules is of the order of 10^8 cm./sec.^{2} or approximately 100,000 times the acceleration of gravity. The maximum movement or displacement as part of the wave motion, however, is less than 10^{-5} cm. for this case. Thus, in a sense, ultrasonic waves are "all acceleration and no motion."

While the pressure variations associated with sound waves are of a periodic nature, a directional radiation pressure is also associated with sound waves in fluids and becomes significant at high acoustical

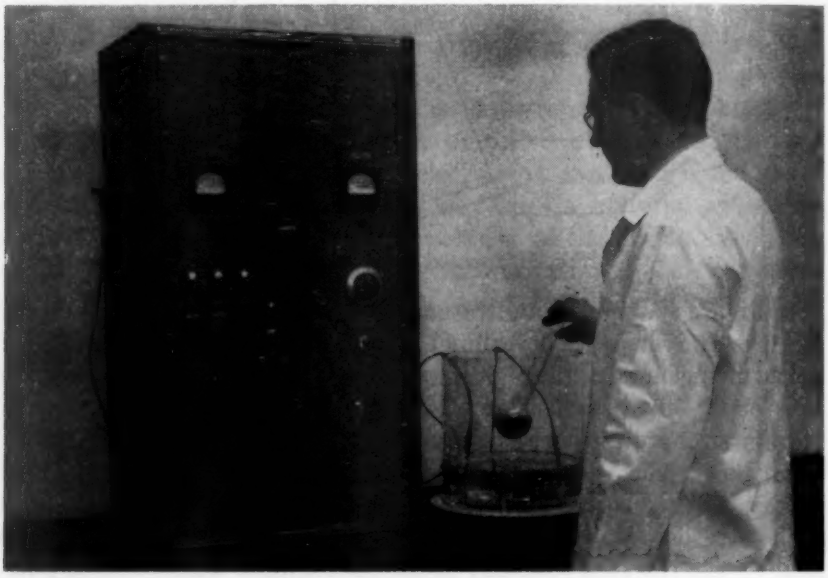


FIG. 4. An ultrasonic generator.

intensities. The radiation pressure exhibits itself in terms of a directional force on any object or surface in the path of the sound waves. This effect is particularly evident if intense ultrasonic waves within a liquid are directed at the surface of the liquid. Figure 5 indicates what happens for the case of ultrasonic waves with a frequency of 600 kilocycles per second and an estimated intensity of several hundred watts per square centimeter. The fountain in this photograph was obtained with the apparatus shown in Figure 4. The barium titanate source has been positioned in the oil bath with the point of convergence

[3] Acoustical intensity represents the sound energy transmitted per second through a plane, one square centimeter in area and perpendicular to the direction of propagation of the sound waves. Intensity has the units of energy per cm.^{2}-sec. and is often expressed in terms of watts/cm.^{2}. For purposes of comparison, the intensity of the sound in air next to the motors of an airplane at take off is approximately 0.0001 watt/cm.^{2}.

of the ultrasonic waves near the surface of the oil. When not confined, the fountain is reasonably dense through a height of 4 ft. with spray extending to the ceiling.

When ultrasonic waves are transmitted through a liquid even at intensities as low as 1 watt/cm.^{2}, the pressure variations associated with the sound waves exceed the total pressure on the liquid if it is at atmospheric pressure. As a result, tensions are produced in the liquid during the rarefactions or negative parts of the pressure cycle associated with the sound waves. In the absence of dissolved gases and specific impurities, it is doubtful whether a liquid such as water

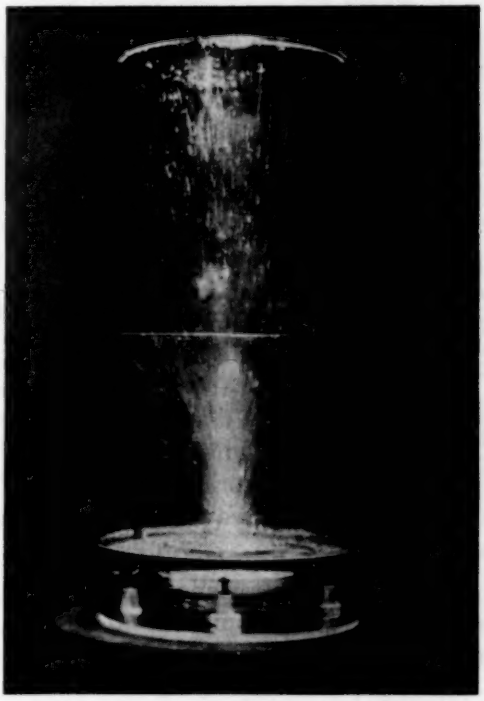


FIG. 5. Fountain produced by intense ultrasonic waves in oil.

would be ruptured even at intensities in excess of 100 watts/cm.^{2} (corresponding to tensions greater than 200 lbs./in.^{2}). If dissolved gases such as air are present in the liquid, these tend to come out of solution during the rarefactions to form bubbles containing both the gases and the vapor of the liquid. This process is often referred to as cavitation in a somewhat liberal sense. The gas bubbles only partially collapse during the compression or positive part of the pressure cycle because the gases do not have a sufficient opportunity to redissolve. Furthermore, during each rarefaction the bubbles grow until probably some critical volume is reached. The pressure within a cavitation

bubble increases from a very low value (associated with the rarefaction in the sound wave) to a relatively high value (associated with the compression) during the extremely short period of one-half cycle or in general less than 10^{-5} seconds. This rapid compression causes the gases in the cavitation bubbles to heat up and to reach instantaneous temperatures as much as several hundred degrees above the temperature of the surrounding liquid. Evidence is available that the chemical effects produced by intense ultrasonic waves are attributable to these high instantaneous temperatures within the cavitation bubbles.

When ultrasonic waves are absorbed within a system, the energy associated with the wave motion is converted into heat. Unless the heat is readily dissipated, the temperature may rise to a point at which the sample undergoes chemical changes. For example, if a small piece of plastic is irradiated with very intense ultrasonic waves, the plastic may heat up internally to a temperature at which the material decomposes with charring, or on occasion explodes despite the fact that the water surrounding the plastic is at room temperatures. This type of progressive heating is distinct from the high instantaneous temperatures involved in the cavitation bubbles. The former can be duplicated by applying heat directly to the system while the latter can not. Progressive heating is undesirable from the standpoint of the chemist because the effects of this type of heating may obscure other effects directly associated with the intense ultrasonic waves. Thus, it is usually important to provide a means for cooling the system in chemical work with intense ultrasonic waves.

The applications of ultrasonic waves in chemistry can be divided into three classifications:

1. the chemical effects of ultrasonic waves,
2. the physical effects of ultrasonic waves, and
3. ultrasonic waves as a tool for the study of chemical systems.

The first classification represents a specific phase of the more general subject of sonochemistry, the production of chemical reactions with sound waves. The second classification is concerned with physical effects which have practical significance to the chemist while the third involves the determination of the properties of chemical systems through measurements with ultrasonic waves.

The Chemical Effects of Ultrasonic Waves

For the most part, the chemical effects of intense ultrasonic waves in liquids depend upon the formation of cavitation bubbles. The relatively high instantaneous temperatures associated with the compression of the bubbles are sufficient to cause the thermal dissociation

of the gas and vapor molecules within the bubbles. When intense ultrasonic waves are introduced into water containing dissolved oxygen gas, substantial amounts of hydrogen peroxide (1) are produced probably as a consequence of the dissociation of the molecular oxygen and the subsequent reaction of the dissociation products with the solvent. The reaction may be represented as follows:

$$O_2 \xrightarrow[\text{sonic}]{\text{ultra-}} 2O; \qquad 2O+2H_2O \rightarrow 2H_2O_2.$$

Similarly, in water containing dissolved nitrogen gas, intense ultrasonic waves produce small but definite amounts of nitrous acid as a result of the dissociation of the nitrogen gas into atomic nitrogen and the reaction of the latter with the solvent (1).

If water saturated with carbon tetrachloride is irradiated with intense ultrasonic waves, free chlorine is liberated provided cavitation bubbles are formed (6, 7). This process can proceed in the absence of oxygen or nitrogen although an inert gas such as helium must be present in the water to permit the formation of cavitation bubbles. While the reaction mechanism is not definitely known, the carbon tetrachloride probably is thermally dissociated as a vapor in the cavitation bubbles. With ultrasonic waves at an intensity of 10 watts/cm.^{2}, this reaction occurs rapidly enough that sufficient chlorine is liberated in less than a second to be detected easily with an indicator such as a potassium iodide-starch solution. Similar reactions have been reported for halogen-substituted methane and ethane.

Ultrasonic waves have also been used to rupture large polymer molecules (2, 6) such as polystyrene, polyvinyl alcohol, and hydroxyethyl cellulose. For example, if a one percent solution of polystyrene dissolved in toluene is irradiated with ultrasonic waves at a frequency of 400 kilocycles per second and an intensity of 1 watt/cm.^{2}, the molecular weight of the polymer can be reduced from an initial value of 7 million to 2 million in less than one hour. The depolymerizing action of ultrasonic waves is contingent upon the formation of cavitation bubbles. Helium-saturated solutions, however, are just as effective as air-saturated solutions.

Many other reactions have been reported to be produced by ultrasonic waves. These include the reduction of potassium permanganate to manganese dioxide (1), the oxidation of organic dyes in aqueous solutions (1), and the rearrangement of benzoyl azide to the isocyanate (3). All of these reactions are dependent on the formation of cavitation bubbles in the presence of the intense ultrasonic waves.

Despite the many chemical reactions which have been reported

in the literature, ultrasonic waves do not seem to be a practical means for producing chemical reactions from the commercial standpoint at the present time. Relatively large amounts of acoustical energy are required and the yields are low. The promise of ultrasonic waves in terms of chemical applications, however, does not lie in the chemical effects but rather in the physical effects and the use of ultrasonic waves as a tool for the study of the properties of chemical systems.

The Physical Effects of Ultrasonic Waves

The most significant physical effects associated with ultrasonic waves in regard to applications of interest to the chemist are the degassing of liquids, the dispersion of solids and liquids, and the coagulation action.

When intense ultrasonic waves are introduced into a liquid containing dissolved gases, the formation of cavitation bubbles effectively removes the dissolved gases from solution After the cavitation bubbles have grown to a reasonable size, they rise to the surface of the liquid and the gas escapes into the surrounding atmosphere. In the case of water and similar liquids, it is not likely that ultrasonic waves will replace techniques such as boiling for removing dissolved gases. Ultrasonic waves may prove practical, however, as a means for degassing fused metals prior to solidification inasmuch as it is very important to have the solid metals free from the holes associated with the liberation of dissolved gases upon freezing. Similar applications should be found in degassing fused quartz to be used for optical purposes.

In the Ultrasonic research Laboratory at Western Reserve University, ultrasonic waves have been used to disperse everything from cooking fats to aluminum in various liquids. Such suspensions are often unstable unless stabilizing agents are present in the liquid since the action of the sound waves is essentially limited to reducing the particle size. The same situation is also encountered with other methods now in use for the preparation of colloidal suspensions. The dispersing action of the ultrasonic waves seems to be dependent on the formation of cavitation bubbles but the exact mechanism is not known.

While ultrasonic waves do not compete in general with existing methods for the preparation of colloidal suspensions, there are specific instances where the acoustical technique offers special advantages over more conventional methods. In the case of two molten metals with limited miscibility, it is often desirable to keep one metal suspended in the other during solidification in order to obtain a solid alloy with a fine structure. This has been accomplished with sound

waves for systems such as lead in aluminum and lead and tin in zinc (1). Likewise, continuous irradiation of a system with ultrasonic waves can be used to keep an insoluble material in suspension in a liquid during the course of a chemical reaction even when it is not possible to prepare a stable suspension. The large surface area associated with the suspension in many cases would increase the rate of reaction tremendously. Personal experience also indicates that ultrasonic waves are a rather convenient means in the laboratory for preparing small quantities of suspensions.

While the formation of cavitation bubbles in liquids tends to favor dispersion, the motion inherent in the ultrasonic waves increases the number of collisions between the colloidal particles already present, and hence, tends to cause coagulation. With liquids, the dispersion effect predominates over the coagulation effect until the particle size has reached some equilibrium value. Thereafter, the two opposing effects probably counterbalance each other. In air, cavitation is not possible and usually only the coagulation effect remains. Hence, if a solid or liquid is suspended in a gas and the system exposed to ultrasonic waves, precipitation may result. Ultrasonic waves have been proposed as a means for smoke precipitation (1).

Ultrasonic Waves as a Tool for the Study of Chemical Systems

Through the measurement of the velocity and absorption of ultrasonic waves as well as sound waves in general, much information has been obtained concerning both inter- and intra-molecular features of structure for gases, liquids, and solids. Velocity and absorption data for gases are valuable in interpreting the relationships between the heat capacity and the various forms of energy possessed by a gas molecule. Similar data for liquids have been used to determine the compressibility of the liquid as well as other parameters characteristic of the structure. For liquid polymers, the molecular weight can be determined from velocity measurements (6). In the case of solutions, velocity and absorption measurements are particularly important in studying the interaction between the solute molecules and the solvent molecules. Ultrasonic waves have been used to obtain information concerning the number of water molecules bound to electrolytic ions in solution (9). Velocity measurements in crystalline solids yield information concerning the elastic constants, and hence, concerning the forces holding the crystals together.

If present trends continue, the day is approaching when the chemist will consider ultrasonic velocity measurements to be a normal part of the study of any new chemical system.

Ultrasonic waves have also been used to study the processes in-

volved in the discharge of electrolytic ions at an electrode (8), the determination of the electrical characteristics of colloidal particles (4), and the rates of chemical reactions (6).

When one field of science finds applications in another field, relatively little time usually elapses before the reverse occurs. Such is the case for ultrasonics and chemistry; the chemist has already made significant contributions to the study of ultrasonics as a phase of acoustics in terms of applications ranging from the development of synthetic piezoelectric crystals for the generation of ultrasonic waves through electrochemical devices for the detection of ultrasonic waves.

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FOREST AND WILDLIFE AREAS IN WISCONSIN

John T. Curtis, professor of botany at the University of Wisconsin, has been elected chairman of the Wisconsin State Board for Preservation of Scientific Areas.

Established by the last Wisconsin legislature, the board was created to formulate policies for setting aside and protecting the forest and wildlife areas in Wisconsin needed for research and teaching.

"This is the first time a state has taken definite steps to carry out a program of total preservation of areas needed for scientific research. It is part of a nationwide movement to preserve indefinitely the areas which represent the major American vegetation types and to include whenever possible the animals as well as the plants," Professor Curtis says.

All of the areas in Wisconsin which are to be set aside for research and instructional purposes, Professor Curtis emphasizes, will be protected in their primitive state as much as possible—there will be no playgrounds, roads, or logging permitted in the areas.

As part of the program, the board will compile and publish an official state list of scientific areas available to those who want to conduct research or who want to include study of the areas as part of instruction in conservation and natural history.

The board will first, however, prepare a list of the Wisconsin areas that need to be put into the scientific areas category and which have not yet been adequately protected.

In all scientific research, Professor Curtis points out, it is of the greatest importance that the areas and the wildlife in them be undisturbed. In almost all instances, disturbance of an area which is being used for any forest or wildlife investigation either decreases the value of the work or destroys it entirely.

PROVIDING A CHALLENGING PROGRAM IN SCIENCE AND MATHEMATICS FOR PUPILS OF SUPERIOR MENTAL ABILITY*

ONA KRAFT
Collinwood High School, Cleveland, Ohio

In this topic: Providing a Challenging Program in Science and Mathematics for Pupils of Superior Mental Ability, the key word is challenging. No short simple formula can be found. Educational writers are still debating about gifted children, as the phrase goes. Is acceleration better or enrichment? Should they be in segregated classes or be given special attention in the regular classes? The weight of current opinion opposes much acceleration, preferring enrichment in special classes if possible.

Special classes limited to the intellectually superior are often administratively impossible. So many choices are made among the academic, technical, and business education courses, majors, minors, and electives, that the variety in programs prevents getting all the best pupils together at the same time. What is generally overlooked is that to a large extent all classes in what is commonly called traditional mathematics are selected classes, becoming more restricted with each grade. Selecting begins down in the ninth grade. Pupils making a poor showing on the algebra aptitude test, or with a low IQ, or with a record of great difficulty in arithmetic are advised not to take algebra, but to elect another kind of mathematics. For plane geometry only the algebra students are eligible, and a geometry aptitude test and plans for the future are considered as well. Only those who elect eleventh and twelfth grade mathematics are enrolled, almost always the college bound, future engineers, teachers, scientists. If everyone were required to study the traditional mathematics throughout high school, the group we now have, especially in the last two years, would be the upper thirty or thirty-five per cent of the class. While special classes for only the gifted would be ideal in many ways, we have an approximation to them now, and the range of ability is not too wide. They can be taught satisfactorily for average pupils and still challenge superior ones.

My contribution to this discussion will not include suggestions for new courses, although I recognize possibilities there. Someone sometime should work out combination science and mathematics courses where the relationship between the two can be better emphasized. Since most of us however deal with superior pupils in regular classes, and since I am a classroom teacher in mathematics myself, I shall

* Read at the Senior High School Group program of the Central Association of Science and Mathematics Teachers, Cleveland, November 24, 1951.

speak entirely from this viewpoint. Some of the other chairmen of mathematics departments in Cleveland high schools have sent me suggestions at my request. To save time I shall not use quotation marks, but I acknowledge the help.

Are special methods needed for teaching the better pupils? Good methods need not be much changed, but poor teaching of the gifted seems to be especially calamitous. In a class of poor pupils with little interest in the lesson, we can be tempted not to try to make them understand but to hand out rules instead. If you derive a formula at the blackboard, the poor pupils probably sit with glazed eyes, unmoved, but the good ones follow, making helpful suggestions, and they look on the formula as their own invention. If you give superior pupils an unexplained formula, they will insist on knowing its origin, and if you brush their questions aside, they may pursue them even to the point of impudence. This principle applies everywhere. Superior pupils are able to understand why things are true, and they want to know why, and it is imperative to satisfy their wish to understand. If they have been frustrated by wrong handling and seem not to be interested, we must make them care.

Assigning problems for homework and spending the next class period having them all done over again on the blackboard is of doubtful value at any time, but is especially resented by good pupils who had them almost all right in the first place. Why not read the answers, finding out which ones were difficult and explaining only those? We teachers should do the hard ones ourselves at the board, explaining each step, or should write them as some pupil does them orally. Meanwhile offer something new to those who had them all right.

Differences in the amount of work that the gifted can do can be handled easily without either making them conceited or discouraging the others. Give fifteen examples on an algebra test, ten of which can be done by anyone who is doing satisfactory work, but make the other five more difficult, and require only ten but offer extra credit for any of the others. Or in a geometry class assign a page of originals, requiring at least three, but offering extra credit for more. Nearly every textbook has topics which are not included in the course of study, or more examples or originals than the average class can manage. Suggest some of these to the better pupils who are ahead on the current work. They will love to explain them to the class. Or send them to the library to look up some mathematician whose name has come up in the lesson.

Good pupils are outraged by having for three or four days in a row homework assignments of exactly the same kind of work which they mastered before they had done half of the first assignment. It is like being compelled to read the same page over and over instead of

getting on with the book. Save the last part of the class period to begin the homework, and find out who had the first three or four problems all right and change their assignment to something different. You are not singling out only the brilliant pupils this way, for any may have mastered the work.

When Dr. Harold Fawcett of Ohio State University began writing of a different way to teach geometry, many teachers were skeptical, but all good teachers now use those principles. Why should any pupil ever memorize a proof all written out in the book? Superior minds recognize instinctively that building up the proof logically is what counts and that memorizing those already jelled is nonsense. Memorizing anything in geometry is seldom necessary, for if a definition or axiom or theorem is really important, the pupils will know it by the time they have hunted it down six or eight times.

We should never forget that what makes superior people superior is that their minds work more quickly or easily or in a different way from others', and that most advances in civilization and culture come from new ideas in superior minds, and never refuse to listen to a different way of doing things. Every original suggestion deserves to be heard and judged. If it was not a good one, its author will now understand why, and if it was good, he will have a warm feeling of accomplishment that will spur him on.

Encourage your pupils to bring in problems that are going the rounds. Talk them over and determine whether they have a mathematical solution or whether one can only guess at the answer.

Many facts in mathematics are so closely tied up with other subjects that only a few words at the right moment will awaken a new interest. Conic sections bring up the paths of heavenly bodies and you can open the door to an interest in astronomy. In the plane geometry class take the opportunity to mention analytic geometry, pointing out how it resembles what they are studying and how it differs from it. Add a few words about non-Euclidean geometry, and projective geometry, too. Spheres tie in with navigation and air travel. Anyone can easily make a long list of such relationships.

Questions impossible to answer in a sentence or two are always being asked us: what is calculus? what is Einstein's theory? how can anything really be infinite? Yet most of these questions grow out of some interest in a superior mind, and if you ignore them or laugh at them, you are muffing an opportunity. Even though you cannot explain calculus very intelligibly to a high school algebra class, you can say enough in a few minutes to whet their appetites, and if you write something on the board with dx's and dy's or sigmas, so much the better.

The question: what good is that? is often annoying, but after all

what more sensible question could anyone ask? It deserves an intelligent answer. Better pupils question everything and reject what appears useless. If we want to merit their respect, we had better find answers to their questions, even though they may sometimes sound a little flippant. Not all superior minds are housed in superior characters, but it is wrong to assume that probing questions from gifted children do not deserve answers.

A row of textbooks by other authors on your desk with occasional references to them encourages the class to look up different ways of handling a particular problem or to find new original theorems to prove or problems to solve. Add other books about mathematics that may interest them. The Lieber books are good for instance, and Vera Sanford's *History of Mathematics*, and a good mathematics dictionary. If SCHOOL SCIENCE AND MATHEMATICS and the *Mathematics Teacher* are made available, those who like puzzles will find some on the high school level. Stress the recreational aspects as much as you can.

Some explanation of the sliderule should certainly be made while logarithms are new, and better yet real use of it should be taught. Frequent references should be made to other mathematical instruments and tools, made familiar with pictures at least, if the actual instruments are not available. Encourage pupils to make any tools for themselves that they can.

Visual aids are prominent in the educational atmosphere, both the ready-made ones and those the pupils can make, and they are an excellent help if it is remembered that they are intended only as aids. I am sometimes afraid that they are so overused that the pupils fail to grasp the abstract aspects of mathematics.

Keep a file of tests that have been used in various contests and when you use items from them in class, explain where you found them and the purpose for which the tests were designed.

Educators tell us that dull people are most comfortable if they can follow a routine without too much thinking on their own part, but that intelligent people cannot endure repeatedly doing things exactly the same way. Any method of conducting a class for better pupils is wrong if it is always used. There should be something different every day.

In so short a paper as this has been, a thorough discussion of the many ways to challenge our better pupils is impossible. I have attempted only to call to your attention some of the methods and materials that are especially appropriate. I could easily add others, and you could contribute many more. All of them can be summed up as illustrating three principles vital in dealing with gifted pupils:

1. Satisfy their wish really to understand mathematics, not merely to learn facts about it.
2. Enrich their learning experience by eliminating unneeded routine and substituting new and interesting material.
3. Take advantage of every opportunity to tie in the current work with other kinds of mathematics, with other subjects, with current affairs, with their own futures; in short, convince them that mathematics is a basic essential on which superior minds can build.

SCHOLARSHIPS AND FELLOWSHIPS AVAILABLE AT INSTITUTIONS OF HIGHER EDUCATION*

THERESA BIRCH WILKINS

Since the last publication of *Scholarships and Fellowships Available at Institutions of Higher Education* by the Office of Education as Bulletin 1936, No. 10, innumerable requests for current information have been received from school and college officials, parents, high-school and college students, and other persons interested in extending college opportunities to greater numbers of capable students.

This bulletin reports information about financial aids for undergraduate and graduate study available at and administered by colleges and universities throughout the country. The information will be helpful to a vast number of students who may be eligible to receive scholarships or fellowships.

* Office of Education Bulletin 1951, No. 16. 248 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 55 cents.

GENERAL ELECTRIC SCIENCE FELLOWSHIPS AT CASE

Case Institute of Technology is now inviting applications for the 1952 General Electric Science Fellowships at that institution. The Fellowship program, which is to be offered for the sixth time this summer, will run from June 23 to August 1.

Fifty all-expense paid Fellowships will be awarded for 1952 which include tuition, board and lodging, and travel expenses to and from Cleveland. High school teachers of physics from the following states are eligible: Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, Western Pennsylvania, Tennessee, West Virginia, and Wisconsin.

Courses to be offered in the six-week's program this summer are: Basic Concepts in Physics, Recent Developments in Atomic and Nuclear Physics, and Science and Technology in the Control of Environment. In addition to the course work, the fellows will devote two afternoons each week to visiting laboratories of the General Electric Company and other outstanding research laboratories in Cleveland.

Application forms may be obtained from Professor Leonard O. Olsen, Department of Physics, Case Institute of Technology, Cleveland 6, Ohio. They must be completed and returned by April 11.

Vinsol resin solution, for use in the concrete mixer to entrain air in the product, results in a concrete filled with minute air bubbles that is highly resistant to weathering, abrasion and frost. Concrete roads with the entrained air bubbles resist the scaling caused by de-icing salts.

THE GENERAL ELECTRIC SCIENCE FELLOWSHIPS FOR HIGH SCHOOL TEACHERS

LEONARD O. OLSEN
Case Institute of Technology, Cleveland, Ohio

This is a description of an interesting and unique experiment in the improvement of secondary school science teaching, and certainly unique in that it was initiated by one of the country's industrial corporations.

The General Electric Co. has supported a six weeks' educational program for high school science teachers each summer since 1945 at Union College in Schenectady, and a similar program at Case Institute of Technology in Cleveland since the summer of 1947. My connections have been with the Case program so my illustrations will be drawn from it; however, these will probably be quite illustrative of the Union College activity also. As far as the sponsoring corporation is concerned, the broad, idealistic goals for these science fellowship courses are identical.

Through the establishment and continuing support of this fellowship program the General Electric Company has displayed that it is willing to devote time and money on positive action to improve American Science and Scientists. It seeks and expects no direct or immediate benefit from this program. As a company making new products based on yesterday's scientific discoveries they realize that their continuing success rests on tomorrow's scientists. How could you better improve these future scientists than by helping their teachers? The General Electric Company is so imbued with this philosophy that they are unwilling to employ any of the science fellows and thus remove them from their all important role of teaching the young scientists—this in spite of their desperate present need for the talents possessed by these teachers.

Over and beyond the fact that they have supplied generous funds, much credit for the success of these Science Fellowship projects belongs to the General Electric Company. Having decided that college Science teachers could best help them attain their objectives they sought their help and then left them free to develop their own methods, subject matter and selection of fellows. The scientists and business experts of the company have generously supplied their time and services when called upon to share their special knowledge and experience with the science fellows.

Each year one hundred high school science teachers spend six weeks on the campus of either Case Institute of Technology or Union College. The fifty at Case are all physics teachers while those at

Union College are divided equally between physics and chemistry. These are *all expense* fellowships and the General Electric Company reimburses the teachers for first class transportation from their homes and return thereto, and pays for tuition and the best lodging and meals which can be supplied. All books and other supplies are also furnished. In addition excellent entertainment is provided along with opportunities to meet personally with outstanding scientists and business men.

When the Physics Department at Case was asked to devote a portion of its summer time in 1947 to a program of courses for fifty high school physics teachers, there was a serious discussion of whether we could accomplish more by doing this or by concentrating on our fundamental research as we had in previous summers. Our staff of teachers are also capable research physicists who are very jealous of research time. Nevertheless it was decided to work with the high school teachers. At Case we devote much of our time to teaching physics to graduates of the secondary schools who hope to become scientist and engineers. We probably get many of the best of these graduates. Even so we continually wish they were better prepared in science and we of course find it easy to blame the high school and its science teachers. Now we were offered a chance to do something constructive under the very favorable conditions which would be possible because of the General Electric Company's grants. We felt we had to accept the challenge!

The geographic distribution of General Electric science fellows for each year and for both Case and Union College is displayed in the accompanying table.

The localities in which fellowships are available have been extended as the programs matured and *last year Case announced the extension of its territory to include Iowa, Minnesota, Missouri and Tennessee.*

The selection of fellows is made by a faculty committee after applications and recommendations have been received. An effort is made to secure the young to middle age teachers with some years of teaching experience because it is felt that these people will benefit most from this experience and will do the most to improve their profession. Secondly, the fellowships serve to reward those who are attempting to do the most for secondary school science teaching. It is all important to get the maximum number of applicants, especially as it is recognized that such a program competes with the near necessity of a potential applicant engaging in summer employment to augment his teaching salary. Several techniques have been tried out but Case now resorts to personal letters to about 5000 high school principals and school superintendents requesting them to nominate teachers of their acquaintance. Personal letters are then written to

the nominees suggesting they apply. In 1950, 3000 such letters resulted in 750 nominations and about 300 applications.

Each year wide publicity is given to the winners particularly in the newspapers of their home towns. This publicity was found to be of particular value as several of the fellows have emphasized that atten-

GENERAL ELECTRIC SCIENCE FELLOWSHIP PROGRAM
GEOGRAPHICAL DISTRIBUTION OF FELLOWS

Case Institute of Technology

States	1947	1948	1949	1950	1951	Total
Illinois	10	14	13	6	6	49
Indiana	8	7	10	9	4	38
Iowa					5	5
Kentucky	2		1	2	2	7
Michigan	8	4	8	10	3	33
Minnesota					6	6
Missouri					7	7
Ohio	15	8	6	13	7	49
Pennsylvania	1	3	2	2	2	10
W. Virginia	1	1	2		1	5
Wisconsin	1	13	7	8	4	33
Total	46	50	49	50	49	244

Union College

States	1945	1946	1947	1948	1949	1950	1951	Total
Connecticut	3	3	6	2	3	4	2	23
Delaware		1						1
Dist. of Columbia				3	3	2		8
Maine	1	3	1	1		1	2	9
Maryland				2	4	2	2	10
Massachusetts	4	9	9	5	8	2	4	41
New Hampshire	1	1	2		1	2		7
New Jersey	4	10	4	6	2	7	1	34
New York	19	13	12	16	14	9	15	98
North Carolina							11	11
Pennsylvania	6	9	11	8	7	8	5	54
Rhode Island			3		1	2		6
Vermont		1	1	2	3	5	2	14
Virginia				5	4	6	6	21
Total	38	50	49	50	50	50	50	337

tion was thereby focussed on physics in their community. They suddenly found themselves lifted out of the unrecognized position in which they performed most of their duties. The regeneration of their deflated ego as a result of the award and its recognition was of as much value to them as anything they subsequently learned in the courses!

Three courses comprise the curriculum. "Basic Concepts of Physics" is devoted to presenting a very few important principles in a thorough manner. As an example the first week is devoted toNewton's Laws of Motion. Great care is taken to insure precise expression and complete understanding of these laws. When a physical quantity is expressed in numbers the necessary unit is always included. Carefully selected problems are assigned in considerable numbers and a dimensional check of these problems is required. Other principles such as conservation of energy, the laws of thermodynamics, and the principle of electromagnetism are treated similarly. All of the emphasis is placed on mastery of the concepts and ability to solve problems therewith.

We are convinced that this course instills a new appreciation for the fundamentals of physics and motivates these teachers to adopt a better, more fundamental approach in their high school classes. Many of these teachers have said "I wish I had been required to be more critical of physical concepts in my earlier study."

This course was initially organized and given by Dean Elmer Hutchisson of Case and by Professor L. Olsen of the Physics Department at Case. During two summers it was given by two outstanding visiting teachers of physics, Professor Richard Sutton of Haverford College and Professor Duane Roller of Wabash College and Harvard University.

The second course is titled "Recent Developments in Atomic and Nuclear Physics" and is under the direction of Professor R. S. Shankland, Head of the Department of Physics at Case. Dr. Shankland's efforts are concentrated on the problems which are of current interest and concern to research physicists. Again emphasis is on understanding. Each year a number of outstanding physicists are secured who explain to the fellows how they are tackling the research problems in which they are currently engaged. This course has been most enthusiastically received as the teachers feel it has given them material which will be useful in interpreting current developments in physics.

In connection with this course a demonstration laboratory is conducted semi-weekly. Modern physical equipment such as Geiger counter circuits, Wilson cloud chamber, scintillation counters, etc. is used. In most cases numerical data are secured which the fellows use to prepare reports on the experiments. Every effort is made to give the fellows as broad an experience with modern physical apparatus as possible.

The third course of the Case curriculum attempts to utilize the advantages of an engineering college to show how modern science is used to improve the standard of living. This course titled "Applica-

tions of Physics in the Control of Environment" is under the direction of Russell C. Putnam, Professor of Illumination Engineering at Case. A portion of this course thus is used to show how man's time is better utilized through modern developments in lighting. Scientists and engineers from the Lamp Department of the General Electric Co. Who are outstanding authorities in the fields of visible, ultra-violet and infra-red radiations have cooperated with Professor Putnam in teaching this portion of the course. Others such as Dr. Cyril Tasker of the American Society of Heating and Ventilating Engineers and Mr. H. A. Erf, Treasurer of the Acoustical Society of America have lectured on "Science and the Control of Environment."

An opportunity is also afforded the fellows to observe and study the use of physics in industry. Two afternoons each week are spent in the modern, excellently equipped Lamp Development Laboratories of the General Electric Co. at Nela Park in Cleveland. In small groups, they study how outstanding researches solve their problems. A visit is also made to the very extensive Lewis Flight Propulsion Laboratory of the National Advisor Committee on Aeronautics.

The extra-curricular activities are very important and merit discussion. These fellows all break their home ties, leaving family and friends and live together as a group for six weeks. They soon make new friends and are engaged with them in lively discussions of the physics they are studying or of mutual professional problems.

The fellows eat their meals together, and their instructors and distinquished visitors join with them and enjoy the informal discussions which this time affords.

An activity director works with the fellows in arranging baseball games and swimming at the outdoor camp of Nela Park. In addition an all day picnic at Case's surveying camp in Mohican State Park is arranged. On several afternoons the General Electric Company supplies entertainment at the outdoor camp followed by a delectable dinner and then an excellent talk by an outstanding member of the General Electric Company. These afternoons make a big impression on these science fellows!—and on the instructors too!

We at Case feel this program is an outstanding success. While we at first hesitated to sacrifice time from research to engage in it, we now feel that there is no other activity which is more fruitful or important. We have gained a keen appreciation of the high school teacher and his problems. We also know how much he benefits if he is fortunate enough to secure one of these fellowships for he returns to his school system as a revitalized teacher with tremendously increased self-respect and renewed respect for his profession. We have

whole heartedly recommended the program's continuance at the conclusion of each summer's program.

The appreciation shown by all of the fellows for what is done for them is a great reward for us at Case and the General Electric Company. Fortunately the enthusiasm sticks with these people too. This is evidenced by the fact that they have spontaneously established General Electric Fellowship Alummi Groups which meet annually in connection with state teachers conventions. Also, most of the fellows of each year have written to personnel of the General Electric Company, or to members of the staff at Case (and also to the staff at Union College) expressing their great appreciation for what was done on their behalf. We conclude by quoting from one of the more eloquent letters received by the Secretary of the General Electric Co.

"May I address myself as one of the teachers on a General Electric Fellowship at Case Institute of Technology and Nela Park last summer? For a year I have desired to express my thanks to the Company for the privilege of being a member of the group which studied in Cleveland, but I have scarcely known to whom I should write. Since I have received several communications from you during the past year, I now address this letter to you.

"To meet a selected group of teachers in one's own field of interest from nine different states, and to study and live with them on intimate terms for a period of six weeks is a privilege. To have as teachers members of the excellent faculty of Case, and men of considerable reputation in their respective fields from General Electric and other institutions; to be in classes arranged especially for the group; and to be given an insight into the activities of a large Company like General Electric makes the privilege rare. To be treated as guests; to be well-housed, well-fed, and well-entertained; and to be given opportunities to grow acquainted with, and become friends of, our instructors and hosts from Case and General Electric is an honor. All of these things were made possible for us through the thoughtfulness and generosity of the General Electric Company. The experience will linger in my memory as one of the important events of my life, and the certificate received at the close of the sessions will be as highly valued as my college diplomas. I wish to extend my sincere thanks to the General Electric Company, and particularly to those individuals responsible for inaugurating and carrying out the Science Fellowship Program in which I participated. I hope that I can do my part in transferring the benefits of the experience to my students."

This program is truly a challenge not only to us who teach it and support it—but to all high school science teachers who honestly desire self-improvement and to all school personnel who seek the improvement of high school standards and who want to pass on this challenge to their teen-age students.

T-square for the draftsman is held in true position on the drawing board by magnetism in a recently patented type. A magnetic metal strip is attached to one end of the board. An elongated permanent magnet, with roller ends, is secured to the T-square straight-edge head piece.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

REPORT OF THE NOVEMBER 22–24, 1951, CLEVELAND CONVENTION

Appreciation: The entire Association is indebted to the Local Arrangements Committee for the 1951 Cleveland Convention. All of the infinite number of details had been foreseen and provided for. From registration right on through checking out the operation had been characterized by subtle smoothness, careful planning, and perfect execution. The Ultra Mixer topped off a truly fine convention. A thousand sincere thanks, Cleveland.

Official appreciation was recorded by a Board of Directors action accepting the plans of the Local Arrangements Coordinator, Harry Mesnick, "with congratulations, and thanks."

It is meet that the Association recognize its indebtedness to the following local chairmen: Ona Kraft, William Kofron, Ann E. Burgess, Ben Levine, Abbie Rush, William Walters, Phil R. Gilman, John Habat, Charles Scott, and M. C. Hanna.

Official Association Meetings

I. The Board of Directors Meeting Thursday, November 22, 1951, 7:30 P.M., Parlor G, Hollenden Hotel

1. Roll Call: Those present included: Officers: Lentz, Peak, Edwards, Soliday, Schreiber, Warner; Past President Meyer; Directors: Brookley, Curtis, Habat, Haggard, Lauby, Leach, Leonhard, Mayor, Pella, Price; Committee Chairmen: Adell, Potzger, Ullsvik; and Past President Baker.

2. Disposition of the November, 1951, Board Meetings Minutes: It was moved (Lauby), and seconded (Peak) that the reading of the minutes of the previous Annual Meetings of the Board of Directors be dispensed with, since these minutes had been published in the Journal.

3(1). Review of Association Affairs: President Lentz: The 1951 Annual Convention of the Association is being put on without cost, relatively speaking. A number of commercial firms have been solicited, and have underwritten the convention expenses. The By-Laws have been brought up to date. There has been no increase in the number of Policy Projects committees. The condition of the various phases of the Association's interests will be brought out in the various committee reports. President Lentz suggested that after the committee reports, the Board of Directors reconvene as a committee of the Board to entertain discussion of the Association's affairs. The report was accepted.

3(2). Local Arrangements: Harry Mesnick: Mr. Mesnick's report was received "with congratulations and thanks," and the work of his splendid committee commended. President Lentz supplemented the Local Arrangements report with the information that Arthur O. Baker had written sixty personal letters of invitation to attend the Convention, Herschel Grime had sent out one hundred and fifty personal notes, Allen F. Meyer had contacted, on behalf of the Saturday group meetings, all four hundred Elementary Science members in the Yearbook, and fifteen dollars had been appropriated for experimental publicity for the Elementary Science Section Meeting. The value in this type of publicity was discussed by the Board.

Mr. Meyer commented that "attendance" should be started on with an educational program and be followed up with the new officers at the Saturday meeting for these new officers. Mr. Leonhard then observed that a "kit" of information be prepared for the incoming sections officers.

3(3). Historian's Report: Edwin W. Schreiber: No names were submitted for Emeritus honors by the Association. Mr. Schreiber plans to submit to the several "veterans" in the Association lists of persons "missing in action" for assistance regarding information for his files. One such a "missing person" Edwin discovered to be hail and hearty at the ripe old age of eighty-one. The dour Schreiber offered

the opinion that none present at the meeting should anticipate such a prospect. His report, and his prospect for us, were accepted by the Board.

3(4). Membership Committee: Harold W. Haggard: Mr. Haggard's fine report was accepted by the Board, and his work highly endorsed. This report stated that the Chairman had been first engaged in organizing a strong committee. They then set out to "sell" memberships. The opinion of these committee people, and of the Chairman, was that the convention publicity should go out not later than September 10th to be effective, and to tie in with the Committee's activities. The following points were considered by the Board: Miss Lauby: Establish an actual membership deadline on which to establish an accurate membership count. Pres. Lentz referred this to Mr. Soliday for his setting of terminal dates on memberships. Mr. Brookley: Non-renewals: Why don't the enrollees stick with this organization? Mr. Price raised the question in reference to Brookley's question, that perhaps non-renewal was in the realm of investigation by a Policy Project committee. The matter was referred to Mr. Peak, Coordinator of Policy Projects.

3(5). Anniversary Publication: John E. Potzger: Although the efforts to sell the remaining copies of the Anniversary Publication have been unproductive to date, the committee does not feel that the job is hopeless. The copies are now selling about one per week. Circulars were sent to libraries, approximately 1500 were contacted, with very little response so far. The Association membership has been contacted via a memorandum. Individual teacher's libraries have been contacted. There have been 583 copies sold, and there are 1417 on hand. The report was accepted.

3(6). Journal Committee: James C. Adell: This sound report was accepted. This committee pointed out that two factors must be faced in increasing the Journal sales, competition and selling the magazine. An eight point program was submitted to increase the salability of our publication: 1, Reviews of new developments in science, 2, Make available "free" materials, 3, Review service on visual aids, 4, Present new class room experiments in short, snappy expositions, 5, Present new activities and new ideas, 6, Summarize ways to teach slow learners, 7, Interest the Big Ten schools of education in our organization, and 8, Direct mail advertising campaign. The suggestion was made, too, that perhaps the greatest opportunity for service, and, hence sales would be in the elementary science and mathematics fields.

3(7). Journal: Glen W. Warner: Mr. Warner urged that since the membership is in direct contact with publishable material, that the membership direct this material to Mr. Warner. Mr. Warner has written to the Convention speakers to direct their copies of their papers to him, and a number have already complied. The report was accepted.

3(8). Yearbook: Ray Agren: Mr. Potzger's suggestion that Mr. Agren be congratulated upon this Yearbook was endorsed by all. The profit this year will be approximately $100.00. The advertising rates went up from $50 to $60. Some ads were lost due to the Convention moving this year to Cleveland. Attention was called to a change this year, the picture of the banquet speaker was used on that page. The possibility of continuing this practice, and of extending it was bandied about with no conclusion being reached. Then, the policy of increasing the range of the advertising types accepted for the yearbook was examined by the Board. It was moved by Peak and seconded by Price that the Board accept Mr. Agren's report, and refer to the Board for further consideration the problem of expanding the scope of Yearbook advertising.

3(9). Treasurer: Ray C. Soliday: Mr. Soliday submitted a mimeographed report, and after considerable discussion of the problems cognate to it, acceptance was moved by Price, seconded by Lauby, and approved by the Board. Mr. Soliday first directed the Board's attention to the fact that the past year's operation had resulted in a loss of $2,586.10. Of this loss $1,098.06 was due to the Anniversary Publication deficit. The Officers and Directors examined in detail the items in the financial statement and devoted some time to analyzing several of

the expense accounts. The influence on the deficit if the Anniversary books were sold was aired, along with the allied problem, selling the present stock of these books. Mr. Potzger and his committee have been and are now diligent in seeking and exhausting every possible means to sell these books.

3(10). Policy and Resolutions Committee: Bjarne R. Ullsvik: This accepted report contained these recommendations: 1, Evaluation of the time limits schedule in all meetings, 2, Continuing the three committees recommended to the Board in May, 1951, on the feasibility of publishing yearbooks, the possibilities in student memberships, and increasing the representation of elementary school teachers on the Board, 3, Recommendations: the Committee on the Significance of Mathematics and Science in Education consider the role of science and mathematics in a common learnings program at the secondary and at the college levels, consider the problems of the small high school, broaden the concept of conservation to include human conservation, and establish an Association committee on public relations. This committee commends for consideration by the Directors the problem of increasing and sustaining membership, the establishment of a committee on advertising, and revision of the time specified in by By-laws for the Annual meetings.

3(11). Policy and Resolutions Committee Projects: Philip Peak: The projects that are active are: Teacher Training, Ella Marth, Chairman; Better Laboratories, Materials and Visual Aids, Philip Tapley, Chairman (Project probably complete, but not ready for publication); and Significance of Science and Mathematics in Education, George G. Mallinson, Chairman (They have a three year program mapped out, but anticipate completion sooner. Mr. Mallinson is reporting on Friday afternoon). The Projects completed and the committees relieved of further obligation are: Teacher Research in Daily Classes, John R. Mayor, Chairman; and Better Evaluation Techniques, Helen M. Monroe, Chairman. Projects suggested but not organized are these three: A Program to Meet Student Needs in Individual Differences, What Behavior Changes Are Effected by Science and Mathematics?, and Methods of Studying Attitudes, Interests, and Appreciations. The two latter have not yet been recommended by the Policy and Resolutions Committee. Some thought was given to publishing the results of the projects committees. Meyer and Price: The results should reach the small schools from whence we derive considerable membership. Lentz: Summarizing is the problem. Peak: 'Tis a shame to waste the effort, after a committee has reported. Ullsvik: Timing is a factor; publication should not be considered after a lapse of, say two years.

3(12). American Association for the Advancement of Science, Cooperative Committee Report: Donald W Lentz: A most excellent report was brought to the Directors and was accepted with thanks and gratitude. The gist of the information is that the A.A.A.S. has recognized its responsibility in the existence of the present, and seemingly the future, acute shortage of "scientific and engineering manpower." Two main areas for action are to be entered: presentation to the Ford Foundation of a scholarship aid program, and publicizing the need and the opportunities in scientific and technical fields through books distributed to all libraries, brochures for wide distribution, and articles in appropriate magazines, journals, etc.

4. Communications: Regrets of the most sincere order, but equally sincere best wishes to the Convention and all their many friends were received (not in time for reception by the Board, unfortunately) from Lucille B. Gates, Charlotte L. Grant, Helen Trowbridge, and Robert L. Ebel.

5. Old Business: Miss Lauby recommended that the awarding a year ago of Emeritus Membership to William David Reeve, distinguished and beloved scholar and teacher, be recorded in the official records. Meyer so moved, Mayor seconded, and the motion was heartily and unanimously approved.

6. New Business: A: Policy Projects Coordinator: Vice President Peak presented for consideration the re-examination of the qualifications of the Policy Projects Coordinator. Everyone contributed suggestions and called attention to

factors to be heeded. Three basic principles were evolved: 1, The Association's vice president should not be the Coordinator, 2, the Coordinator's term in office should have continuity, and 3, the Coordinator should have "official status" in the Association. President Lentz summarized the discussion in a proposal that the Policy and Resolutions Committee bring a proposal to the Board of Directors at the Spring, 1952, Meeting covering the selection of the Projects Coordinator on the basis of three factors, 1, Continuity, 2, Continuity to cover a three year period, and 3, The Coordinator's official Association status, whether a Policy and Resolutions member, whether a Board member, whether the Vice President, etc.

6. New Business—continued—B. Emeritus Membership: The general agreement was that the Board of Directors authorize the bestowing of Emeritus Membership upon retirees that the Board declares eligible for this honor and distinction.

The Board of Directors upon a motion by Mayor and seconded by Leach, conferred Emeritus Membership upon our true friend, honored and distinguished member, Past President of our Association, and Master Teacher:

WALTER GEORGE GINGERY

A recess was called at 10:45 P.M. The Board of Directors reconvened after the recess at 11:00 P.M.

The budget, in total and in its several parts, and the implications thereof, were given the full and considered attention of the Directors. Board action was taken on three proposals: 1, The motion was defeated that the Business Manager be directed to provide no fees for convention speakers next year (1952). The motion was carried that the Business Manager and the Editor prepare analyses for purposes of record of their duties in their respective offices. The motion passed that Directors travelling expenses be eliminated for the Spring, 1952, Meeting of the Board of Directors.

Adjournment at 1:15 A.M. on Friday, November 23, 1951.

II. The Annual Business Meeting

Saturday Morning, November 24, 1951, at 8:30 A.M. in Parlor C

1. Disposition of the Minutes of the Official Meetings at the 1951 Chicago, Illinois, Convention: President Lentz called the meeting to order, and asked the group's pleasure regarding the reading of the 1951 Convention Minutes. It was approved that their reading be dispensed with, since the proceedings had been duly publicized in the Journal.

2. Necrology Report: Edwin W. Schreiber: Mr. Warner stated that Miss Alma Laird had passed away. The Convention directed that Mr. Warner write and have printed in the Journal an appropriate memoir in tribute to Miss Laird.

3. Committee Reports:

   a. Membership: Harold W. Haggard: Members registered, 317. Guest registrations, 76. Membership dues collected $317.50. Attendance was about 60% of the 1950 Convention. Total membership, 1183.

   b. Anniversary Publication: John E. Potzger: No books sold at the Convention. His committee plans pressing a campaign to get the books moved.

   c. Place of Meeting: W. R. Teeters: An invitation to hold the Convention in Cincinnati was received from a Cincinnati hotel, and an invitation was received from the Chamber of Commerce of Milwaukee, Wisconsin. The Committee's suggestion that the 1952 Convention be held in Chicago, Illinois, was approved.

   d. Nominating Committee: Robert S. Langton: The recommendations of this committee were approved:
   For President: Philip Peak, Indiana University, Bloomington, Ind.
   For Vice President: Fred D. Leonhard, Redford High School, Detroit, Mich.

For Directors, Terms Expire in 1954,
Ella Marth, Harris Teachers College, St. Louis, Mo.
Charlotte Junge, Wayne University, Detroit, Mich.
Winnafred Shepard, Proviso Township High School, Maywood, Ill.
Glenadine Gibb, State Teachers College, Cedar Falls, Iowa.
For Director, Term Expires in 1953, replacing Mr. Leonhard, Walter W. Lauterbach, Central High School, South Bend, Ind.
These persons were introduced, and Mr. Peak responded to his elevation to the Presidency of the Association.
President Lentz commended the Nominating Committee for their earnest attention to and recognition of their responsibilities.

e. Revision of the By-laws: Marie Wilcox: This Committee reported two recommendations to the Board of Directors at the May 12, 1951 meeting, the revisions as revised by the Directors in that meeting and as accepted by the Committee were printed in two issues of the Journal. These revisions were accepted by the Convention and are as follows:

Section II of Article III be amended to read:

"Nominees for the offices of president and vice president must have been officers and/or members of the Board of Directors within the past five years."

Section IV of Article V remain as it now is.

There was discussion from the floor against the recommendations on the grounds that the area from which to select presidential timber was too restricted, and hence that the amendment should be more liberal. A question was asked if there is an operative policy to move the vice-president up to the presidency, and the "answer" was "apparently not," there was no knowledge or evidence of such a policy. The fact was called to the Convention's attention by Pella that the Association's meetings have not legally conformed to the By-laws. This discrepancy was referred to the 1952 Committee on the Revision of the By-laws.

President Lentz expressed his most sincere thanks and appreciation to every one in the Association for their loyal support and their constant willingness to pitch in and help whenever called upon.

Adjournment: 9:05 A.M.

III. The Board of Directors Meeting

Saturday, November 24, 1951 at 1:45 P.M. in Parlor D

1. Roll Call: Officers Present: Peak, Leonhard, Edwards, Soliday, Warner, Meyer, Lentz; Directors: Brookley, Curtis, Gibb, Habat, Haggard, Junge, Lauby, Lauterbach, Marth, Mayor, Pella, Price, Shepard; and Chairmen, Lefler and Mesnick.

Journal Committee: The possibility of using offset printing for the Journal was discussed at some length. Format changes came in for consideration. Liberalizing the types of advertising accepted for the Journal was suggested, and thought over. Two actions were taken: 1, A committee is to be appointed with the Business Manager as chairman to study the matter of using offset printing for the Journal. This committee is to report to the Board at the Spring, 1952, meeting, 2, The Journal Committee is directed to report to the Board at the Spring, 1952, meeting on suggested desirable changes in the Journal format, and on desirable changes in broadening the base of the advertising accepted for the Journal.

Finances: Individual responsibility should be taken in the matter of furthering the sale of Anniversary books and Association memberships.

Place of Meeting: The Board indicated a strong preference for the 1952 Chicago Convention to be held in a loop hotel. President-elect Peak was instructed to thoroughly investigate this possibility. The Place of Meeting Committees in the future are to be instructed to plan the place of meeting two years in advance

by action of this Board of Directors.

Supplementary Publications Committee: Ralph W. Lefler: The Board accepted this committee's report in which five recommendations were made: 1, Nothing should be published resembling any present or past publications, 2, No attempt should be made to compete with any present commercial publication, 3, There should be cooperation with existing professional groups that are publishing, 4, There seems to be a possible market for "teacher aid" type of material, and 5, (a), Make use of the great wealth of past years Journal material in certain scientific areas in the form of concise summary digests, and 5(b), enter especially the field of elementary mathematics.

Local Arrangements: Harry Mesnick: Mr. Mesnick very generously and graciously (and typically so) suggested that he write up for the benefit of the Association his trials and tribulations as Local Arrangements Coordinator. This very valuable and useful offer was accepted with thanks.

Student Exhibits: John E. Habat: Mr. Habat made the significant suggestion that if, and whenever possible, future local arrangements planners meet with as many of the preceding year's members as possible. President Lentz then expressed to Mr. Habat the appreciation and the utmost commendation of the Association for Mr. Habat's service on the local committees, and for his outstanding gem, the student exhibits. Student Membership Committee: The chairman could not be present at the Convention, and there was no report submitted.

Saturday Morning Meetings Committee: Cecelia Lauby: The committee of Lauby, Curtis, Davis, and Grime made this timely and excellent report:

> 1, The original purposes of the Central Association of Science and Mathematics Teachers were to improve classroom teaching and to assist teachers to become better teachers, 2, The program planning was set up to achieve these objectives: a, The teaching problems were selected, b, Speakers were obtained to address these problems in special interest areas, that is, in section meetings, c, The implications of these problems, and the implications of the data, information, and interpretations presented by the sections speakers were thought through in the Group Meetings on Saturday morning, and d, The program planning was done by the president, the officers, and the section chairmen.

Miss Curtis observed that on the basis of this report "Conservation" was a "section" and not a "group."

President Lentz then became Past President Lentz, and President-elect Peak became President Peak.

Adjournment: 3:15 P.M.

Respectfully submitted,
W. H. EDWARDS, *Secretary*

THE SECTIONS MEETINGS

Biology

Presiding: Frances M. Gourley, La Porte High School, La Porte, Ind.
Reported by Nelson L. Lowry, Arlington Heights High School, Arlington Heights, Ill.

The Nominating Committee of Mr. Brookley, Chairman, Mr. Bos, and Mr. McCafferty presented a slate that was unanimously elected. The new 1952 officers will be Ruby E. Fremont, Chairman, Nelson L. Lowry, Vice Chairman, and James H. Otto, Secretary.

The first program feature was Dr. Richard Armacost, Biology Department, Purdue University. The problem considered and very ably handled was actual classroom materials and usable references that a teacher may employ in making the study of genetics interesting. He did a fine job. Dr. Harry J. Fuller was the second feature on the program, and his material likewise received top rating by the section. His film, "A Botanist in the Andes," and his running commentary simply transported everyone right across time and space into the Andes region of his lecture.

Attendance: 60.

Chemistry

Presiding: Gerald Osborne, Western Michigan College of Education, Kalamazoo, Mich.

Reported by T. A. Nelson, Lyons Township High School, La Grange, Ill.

This section's Nominating Committee selected to serve in 1952: Sylvan L. Mickelson, Chairman, T. A. Nelson, Vice Chairman, and Robert A. Grubbs, Secretary. The Committee was made up of G. P. Cahoun, Chairman, Fred Calhoun, and George Mallinson, and their nominees were elected.

Dr. Ernest B. Yeager very ably discussed a new phase of Chemistry in his talk, "Applications of Ultrasonics in Chemistry." Several interesting experiments were performed which added clarity to his remarks about properties of ultrasonic waves and applications of their effects. This lecture was well received.

Dr. J. A. Campbell of Oberlin College followed Dr. Yeager's fine work with another excellent piece of lecturing. Dr. Campbell's handling of models and slides for use in elementary chemistry was skill at its best, and very interesting. His interpretation of his material into classroom use was appreciated by all.

Attendance: 77.

Elementary Mathematics

Presiding: Ella Marth, Harris Teachers College, St. Louis, Mo.

Reported by Glenadine Gibb, State Teachers College, Cedar Falls, Iowa.

John R. Mayor was Chairman of the Nominating Committee and his colleagues were F. Lynwood Wren and Ona Kraft. Their recommendations were accepted by the section and included: Ella Marth, Chairman, Glenadine Gibb, Vice Chairman, and Herschel Grime, Secretary.

Dr. Herschel Grime presented "A Pictorial Visit to the Elementary Mathematics Classroom." His material was drawn from the activities and operations included in the arithmetic curriculum centers of the Cleveland Public Schools. There are four phases of this in-service training program, 1, Demonstration plans via radio, 2, Listing of course of study and objectives, 3, Help given to teachers in evaluating their work, and 4, Schedules for teachers visiting the centers.

Mrs. Marcella McNerney, the Principal of the Arithmetic Curriculum Center, addressed her attention to the use of radio in in-service training of teachers. The point she developed was that the radio was particularly effective in inaugurating a new course of study, and in helping new and "reconverted" teachers.

This section was treated to two interesting and able speakers.

Attendance: 70.

Elementary Science

Presiding: Albert Piltz, Roosevelt Elementary School, Detroit, Mich.

Reported by Ella Nichols, Alma Elementary School, Alma, Mich.

Between the two divisions of our program the Nominating Committee brought in for consideration a staff that was immediately favored by the section to be its officers for 1952. The new Chairman will be Ella Nichols, the Vice-Chairman, Muriel Beuschlein, and the Secretary, Louis Rzepka.

Dr. Wilbur Beauchamp set the stage for the factors to be considered in "Teaching Science Generalizations." Dr. Beauchamp is always Dr. Beauchamp, namely the best in his field. Consequently, the panel was led and inspired to do a superlative job, which they proceeded to do.

Attendance: 60.

General Science

Presiding: Fred W. Fox, McGuffy High School, Miami University, Miami, Ohio.

Reported by Sister Mary Ellen O'Hanlon, Rosary College, River Forest, Ill.

The people directing our section in 1952 will be Bert E. Grove as Chairman, Sister Mary Ellen O'Hanlon as Vice-Chairman, and Marjorie Barnes as Secretary. These officers were selected for consideration and honor by our section by Julian Greenlee, Chairman, Harley Mutzfeld, and Paul Loos.

Herbert P. McConnell's paper on Photography as a Teaching Tool and Student

Activity in General Science was interesting, novel, and well delivered. The comparative ease and the real advantage in presenting through photography otherwise unavailable material was featured.

Dr. Milton Pella brought to his subject, the Use of Laboratory Activities in Teaching General Science, the astuteness and the painstaking thoroughness that characterize whatever he addresses himself to. The place of the teacher as a guide in the learning of general science, in contrast to "teller of information," was ably presented. The paper on Ohio School-Forest Program did a real selling job on at least two counts, 1, the actuality of the conservation problem to individuals, and 2, a school or class can plan and execute a significant conservation activity or program. Dr. Carl S. Johnson, the speaker, never had the thought in his mind, but we were all sold on him, too.

Attendance: 75.

Mathematics Section

Presiding: Enoch D. Burton, Shortridge High School, Indianapolis, Ind.
Reported by Geraldine Dolan, Cass Technical High School, Detroit, Mich.

The gentlemen that selected the nominees for the Mathematics Section had Walter Barczewski Chairman, aided by Charles L. Butler, and Stanley F. Schenk. Their choices for the 1952 posts were Chairman, Ona Kraft, Vice-Chairman, Geraldine Dolan, and Secretary, Reino M. Takala. These people were elected.

Dr. Fehr, Head of the Department of the Teaching of Mathematics in Columbia University, developed the thought that so often we are so busy teaching the "necessary" mathematics that we lose sight of developing appreciation. Appreciation, he stated, is evidenced in five ways, 1, Responsiveness to the mathematics in the phenomena around us, 2, an inner compulsion to "apply" mathematics, 3, an awareness of the best method to use in a mathematical situation, 4, growth of mathematical ability, and 5, mathematical insight. This was an excellent discussion that the classroom teacher can use as a background for reflective thinking when evaluating his own activities in the classroom.

Attendance: 86.

Physics

Presiding: Delia Redman, New Haven High School, New Haven, Ind.
Reported by Kenneth E. Vordenberg, Board of Education, Cincinnatti, Ohio.

A committee of three, Louis Panush, T. A. Nelson, and W. N. Smith met to choose the Physics Section officers for next year. Their slate was immediately approved by the electorate, and the following will guide this section's destiny at the next convention: S. Fred Calhoun will be Chairman, Kenneth E. Vordenberg will be Vice-Chairman, and G. A. Waldorf will be Secretary.

Mr. John Brierly of the Sperry Gyroscope Company gave an illustrated lecture on the gyroscope and its principles. The limitations of the gyro as a stabilizer on ships was pointed out. In the second part of his talk, Mr. Brierly discussed at length the gyro-compass and its uses.

Modern aircraft instruments employing the gyro principle were demonstrated by Mr. William J. Dooley at the close of the meeting. Mr. Dooley is in the Cleveland offices of the Sperry people.

The second part of the program was given over to a panel discussion devoted to Current Materials for Teaching Science. The director of the panel was John S. Richardson of Ohio State University. His supporting cast was represented by R. D. Stanton, General Electric Company, Hartley Howe, Popular Science Magazine, Gordon F. Vars, Bel Air, Maryland, High School, and Ralph W. Lefler, Purdue University. Mention should be made of the points brought out by the panel in direct reference to use of current materials. These items were, 1, Materials from industry reach millions of readers, and greatly supplement their fundamental scientific knowledge, 2, Industry welcomes teacher evaluation of these supplementary materials, 3, The current use of materials should be in three areas: classroom instruction, extra class activity, and home activity, 4, In the classroom use may be made through conferences, reading table, bulletin board,

and student activity, 5, In extra class activity the laboratory should be open like other parts of the school for more effective after school use, and for improved public relations, 6, Activity materials and laboratory equipment should be made available to students for home activity, and 7, More effective use should be made of resource persons in the community.
Attendance: 150.

GROUP MEETINGS

Group meetings were held in these divisions, Elementary School, Junior High School, Senior High School, Conservation, and Junior College. The programs were very carefully planned and well executed. The speakers were uniformly excellent. Their papers will be published in the Journal. The attendance was fair, and it is unfortunate that more could not have attended these fine meetings.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2261, 4, 5, 7, 8. *C. W. Trigg, Los Angeles City College*

2262. *Irving Shipkowitz, Chicago; Donald Weinberg, Chicago.*

2263. *C. W. Trigg, Los Angeles City College; Richard H. Bates Milford, N. Y.; John A. Henderson, Centre Hall, Pa.; Walter R. Warne, Minneapolis, Minn.*

2266. *Hugo Brandt, Chicago; Cecil B. Read, University of Wichita.*

2269. *Proposed by Howard D. Grossman, New York.*

A circle of radius 15 intersects another circle, radius 20 at right angles. What is the difference of areas of non-overlapping portions?

Solution by Joseph Kennedy, Greenfield, Ind.

Let

a = area of larger circle

b = area of smaller circle

x = common area.

Then

$a-x$ = non-overlapped area of larger circle

$b-x$ = non-overlapped area of smaller circle

and

$$\begin{aligned}(a-x)-(b-x) &= \text{difference of non-overlapped area}\\ &= a-b\\ &= 175\pi\\ &= \text{difference of areas of the circles.}\end{aligned}$$

Solutions were also offered by: Charles McCracken, University of Cincinnati; Hugo Brandt, Chicago; C. W. Trigg, Los Angeles City College; V. C. Bailey, Evansville College; Richard H. Bates, Milford, N. Y.; Leon Bankoff, Los Angeles; James F. Gray, Kirkwood, Mo.; A. MacNeish, Chicago; Martin Hirsch, Brooklyn; Boyd Henry, Parsons College; and also the proposer.

2270. *Proposed by V. C. Bailey, Evansville, Indiana.*

Show that $\pi/4 = \arctan 1/2 + \arctan 1/5 + \arctan 1/8$.

Solution by Cecil B. Read, University of Wichita, Wichita, Kan.

Let $\arctan 1/2 = \alpha$, $\arctan 1/5 = \beta$, $\arctan 1/8 = \gamma$, then $\tan(\alpha+\beta) = 7/9$ by the formula for the tangent of the sum of two angles, and likewise $\tan[(\alpha+\beta)+\gamma] = 1$. Hence $\alpha+\beta+\gamma = \arctan 1 = \pi/4$ provided we restrict to principal values; otherwise the statement is not true as for example if α is selected in the third quadrant. This is reported to be the formula by which Dase of Germany computed α to a very large number of decimal places.

Solutions were also offered by: Martin Hirsch, Brooklyn; Hugo Brandt, Chicago; Charles McCracken, Jr., University of Cincinnati; Richard H. Bates, Milford, N. Y.; Nicholas Kushta, Arlington Heights, Ill.; Leon Bankoff, Los Angeles; James F. Gray, Kirkwood, Mo.; A. MacNeish, Chicago; C. W. Trigg, Los Angeles City College; Marjorie Baker, Bangor, Me.; Walter R. Warne, Minneapolis; James Means, Austin, Tex.

2271. *Proposed by V. C. Bailey, Evansville, Ind.*

Solve the equation:

$$64\sin^7\theta + \sin 7\theta = 0.$$

Solution by James F. Gray, Kirkwood, Mo.

Use the binomial theorem to expand the right member of the following, and equate imaginary parts:

$$\cos 7\theta + i\sin 7\theta = (\cos\theta + i\sin\theta)^7$$

whence

$$\sin 7\theta = 7\sin\theta\cdot\cos^6\theta - 35\sin^3\theta\cos^4\theta + 21\sin^5\theta\cos^2\theta - \sin^7\theta.$$

Replacing $\cos^2\theta$ by $1-\sin^2\theta$, expanding, and collecting terms,

$$\sin 7\theta = 7\sin\theta - 56\sin^3\theta + 112\sin^5\theta - 64\sin^7\theta.$$

Substituting in

$$64\sin^7\theta + \sin^7\theta = 0$$

we get

$$7 \sin\theta(1-8\sin^2\theta+16\sin^4\theta)=0$$

and

$$\sin\theta=0, \qquad \sin\theta=\pm\tfrac{1}{2}$$

whence $\theta=0$, 30, 150, 180, 210, 330, 360 degrees.

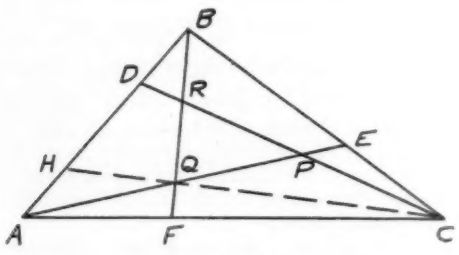
Solutions were also offered by: C. W. Trigg, Los Angeles City College; Hugo Brandt, Chicago; Leon Bankoff, Los Angeles; Cecil B. Read, University of Wichita; Nicholas Kushta, Arlington Heights, Ill.

2271. It is the hope, that a complete solution of this problem may be offered next time.

By use of tables Richard D. Crowley Jr., Harrisburg, Pa. offered a verification.

2273. *Proposed by Alan Wayne, Flushing, N. Y.*

Let points D, E, and F be taken on the sides AB, BC and CA, respectively, of triangle ABC so that $AD/DB=r$, $BE/EC=s$, and $CF/FA=t$. If AE and CD intersect in P, BF and AE intersect in Q, and CD and BF intersect in R, express the ratio of the area of triangle PQR to the area of triangle ABC as a function of r, s and t.



Solution by C. W. Trigg, Los Angeles City College

Draw CQ extended, meeting AB in H. By Ceva's Theorem,

$$BH/HA=(BE/EC)(CF/FA)=st.$$

Then $BQ/QF=BH/HA+BE/EC=st+s$. [See, Altshiller-Court, *College Geometry* (1925), page 131.] It follows that

$$BQ/BF=BQ/(BQ+QF)=(s+st)/(1+s+st).$$

Now

$$\triangle AQB/\triangle AFB=BQ/BF$$

and

$$\triangle AFB/\triangle ABC=AF/AC.$$

Since

$$AF/FC=1/t, \qquad AF/AC=AF/(AF+FC)=1/(t+1).$$

Therefore,

$$\triangle AQB/\triangle ABC=s/(1+s+st).$$

In like manner, it may be shown that

$$\triangle BRC/\triangle ABC=t/(1+t+tr)$$

and

$$\triangle CPA/\triangle ABC=r/(1+r+rs).$$

From the figure,

$$\triangle PQR/\triangle ABC=(\triangle ABC-\triangle AQB-\triangle BRC-\triangle CPA)/\triangle ABC.$$

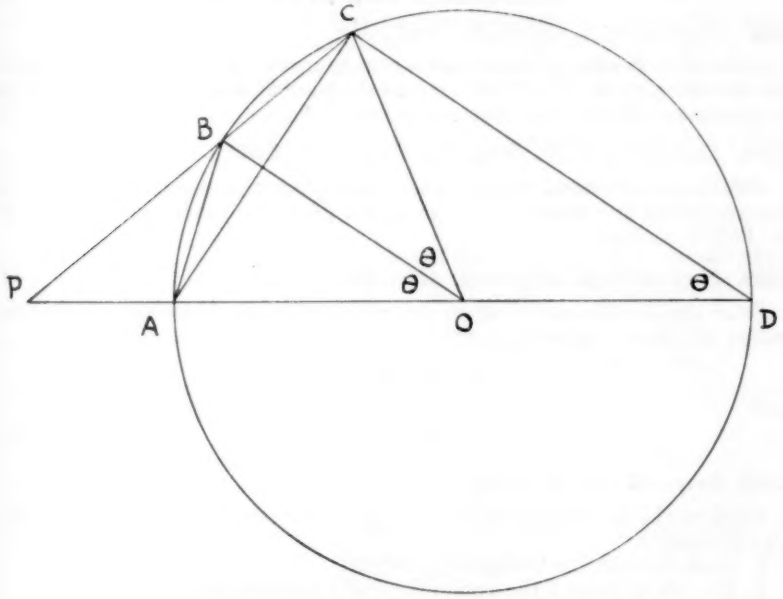
Then

$$\triangle PQR/\triangle ABC=1-s/(1+s+st)-t/(1+t+tr)-r/(1+r+rs)$$
$$=(1-rst)^2/(1+r+rs)(1+s+st)(1+t+tr).$$

Other solutions were offered by: Hugo Brandt, Chicago; Martin Hirsch, Brooklyn, N. Y.

2274. *Proposed by Alan Wayne, Flushing, N. Y.*

Let AB and BC be adjacent sides of a regular polygon whose center is 0 and whose interior angle is θ. Segments AO and BC are extended (if necessary) to meet in point, P, show that $PC/BP=2\cos\theta$.



Solution by Leon Bankoff, Los Angeles, Calif.

PO produced intersects circumference of circumscribed circle in D. Draw DC, OB, OC and AC. In triangle PCO, OB bisects angle POC. Hence,

$$PB/BC=PO/OC.$$

Since $OC=OD$,

$$PB/BC=PO/OD.$$

it follows that OB and DC are parallel and that angle $PDC=$angle $POB=\theta$. In right triangle ACD, $\cos ADC=\cos\theta=DC/AD=DC/2OB$. Hence,

$$DC/OB=2\cos\theta.$$

Since triangles POB and PDC are similar,

$$DC/OB=PC/PB=2\cos\theta.$$

Other solutions were offered by: Charles McCracken Jr., University of Cincinnati; Richard H. Bates, Milford, N. Y.; James F. Gray, Kirkwood, Mo.; Hugo Brandt, Chicago; V. C. Bailey, Evansville; Charles W. Trigg, Los Angeles.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

W. M. H. Grover, Toronto
Stuart P. Godwin, Toronto
R. A. Gorman, Toronto
Janice A. Egeland, Harrisburg, Pa. Catholic H. S.

PROBLEMS FOR SOLUTION

2287. *Proposed by S. Zucchi, Kirksville, Mo.*

Eight players attempt to arrange a card tournament with two players playing against two players. What is the maximum number of games to be played, with no two games having the same opponents.

2288. *Proposed by C. W. Trigg, Los Angeles City College.*

ABC is an equilateral triangle, and P is any point on the circumference of its incircle. Using the theorems of high school geometry prove that $(PA)^2+(PB)^2+(PC)^2$ is constant.

2289. *Proposed by W. R. Warne, Alton, Ill.*

Show that for the pair of equations which follow there are no real or complex values of x and y satisfying both:

$$yx^3+(3y+1-y^3)x+y=0$$

and

$$x^2-y^2+3=0.$$

2290. *Proposed by C. W. Trigg*

Confirm the following properties of the third row (1, 3, 6, 10, . . .) of the Pascal triangle.

1. Each element is a triangular number.
2. The nth element is the sum of the first n elements of the second row.
3. The sum of two consecutive elements is a square number.
4. The sum of the first element and eight times any other element is a square number.
5. The difference of the squares of two consecutive elements is a cube.
6. Twice the nth element added to the $(n+1)$th element of the second row yields a square number.

2291. *Proposed by Charles McCracken Jr. University of Cincinnati.*

Show that a number of the form $9n+5$ cannot be a perfect cube.

2292. *Proposed by Hugo Brandt, Chicago.*

If 1, 2, 3, 10 are the first four terms of an algebraic sequence, find a formula for the general (A_n) term.

2293. *Proposed by Walter H. Carrahan, Lafayette, Ind.*

A plane of unlimited extent is covered by a checker board pattern of 1.5″ squares. If a penny (diameter .75″) is dropped at random, what is the probability that the penny will overlap a vertex?

NOTE. The above problem relates to one of the well-known statistical methods for determining the value of π.

BOOK REVIEWS

LITERARY STYLE AND MUSIC, by Herbert Spencer. Cloth. Pages x+119. 10×16.5 cm. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y.

This is a republication, in booklet form, of Spencer's essays first printed in 1852 and 1857. There are four of them: *Philosophy of Style* (originally called "Force of Expression"), *The Origin and Function of Music*, *Gracefulness*, and lastly *Use and Beauty*.

Of these, the first and the last may have an appeal to those whose chief interest is in science. The first by virtue of its practical suggestions regarding forcefulness and clarity in expository expression, and the last by its intriguing suggestion that there is a sort of evolution evident in the transition of that which was once useful to that which is now more acceptable in art as the beautiful.

The book has a four page introduction by Charles T. Smith. It is pocket size and is interestingly written; in other words, here is enjoyable reading as well as intellectual profit.

B. CLIFFORD HENDRICKS
Longview, Washington

THE SEA HUNTERS, INDIANS OF THE NORTHWEST COAST, by Sonia Bleeker. Cloth. 159 pages. 12.5×19 cm. 1951. William Morrow and Company, Inc., 425 Fourth Avenue, New York 16, N. Y. Price $2.00.

This is the third in the author's series on the North American Indian tribes. The two preceding are *Indians of the Longhouse* and the *Apache Indians*.

The Indians of the northwest could not be farmers since their land was almost wholly the narrow shore between the ocean and the high mountains. In consequence their existence was made possible by animal life taken from the sea. This book depicts, in simple phraseology readable by boys and girls of the elementary grades, the daily life of these primitive people before the arrival of the white man. Their mechanical achievements without benefit of metals; their food acquisition and preservation, and their social life centered around what are called "Winter Ceremonials," are described in such detail as to give a ready appreciation of the intimate life of these people.

The author is an anthropologist who has made the North American Indians her special field of study. Fifty or more handdrawn illustrations and three double columned pages of index add to the book's value for school use.

B. CLIFFORD HENDRICKS

THE YOUNG SCIENTIST—ACTIVITIES FOR JUNIOR HIGH SCHOOL STUDENTS, by Maitland P. Simmons, *B.Sc., M.A. Science Department, Irvington High School, Irvington, New Jersey, Formerly Instructor in General Science, Junior High School, Everett, Massachusetts.* With an Introduction by Arthur Luck, Michigan State College. 164 pages. Exposition Press Inc., 1951. $3.00.

This is a *science activity* book for ninth graders, designed to be used with any standard ninth grade general science textbook. The experiments run a pretty wide gamut of subject matter under units entitled: Air, The Earth's Crust, Heat, Composition of Matter, Forces of Nature, Water, Foods, Light, Machines, Sound, Electricity, Plant Life, Animal Life. It is liberally illustrated with pencil

sketches excellently self-explanatory. The equipment is commonplace and hence within the reach of the least adequately equipped school set-up. If a youngster pursued every one of these experiments under the guidance and direction of a good teacher he would be beautifully prepared to follow the more elaborate expositions in science.

The experiments are well arranged and adequately described. The many questions incite the thinking process. Considering the level to which these matters are addressed the language is proper although not always *exactly sound.* Many of the questions could lead the inquisitive student into the higher flights. For example: "Why is a fish able to ascend and descend at will in water?" If this single inquiry excited the imagination of a student it could lead him to a seat with Agassiz. I hope that the teacher who uses this little volume equips himself adequately in these fields of knowledge.

Mr. Simmons has made a very worthwhile contribution to elementary science instruction.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

EXTENDING HORIZONS—HOW THE NEW REVELATIONS MAY PIERCE THE CURTAIN OF IGNORANCE. By Porter Sargent. 190 pages. Porter Sargent, 11 Beacon Street, Boston Massachusetts. 1950. $2.00.

Those who know Porter Sargent's writings need no briefing. Those who do not have been missing something. Sargent writes daringly, with insight and utter freedom. His assays are pungent and always of a fighting temper. The courage and independence of his utterances are often frightening for few of us would dare say it.

There have been a host of Porter Sargent books, some with titles thus: *Dangerous Trends; Mad or Befuddled?; Doubt and Other Things.* His handbooks on private schools are as well known (in New England, at least) as clam chowder and baked beans.

The present volume contains some gems. I quote at random:

"The sorry tale of our public schools . . . "

"Our teachers spew out words. They have been fed on mere verbiage."

"The pupils . . . have become morally and spiritually anemic."

"In this wasteland of professional pedaguese. . . . "

And the titles of some of the essays:

"Politically Adolescent"; "Our Sick Society"; "What Passes for Education"; "Educational Underworld"; "A Stultifying Diet"; "Intellectual Suicide"; "Withholding Food Facts"; "Who Shall Teach"; "Suppressing Scientists"; "Threats to Freedom."

Mr. Sargent provides us here also with a list of books which have brought *him* inspiration and excitement, but which, he suggests, remain unknown to those who have been subjected to the "disciplines" of the "humanities" in our universities.

Again I say, if you do not know Porter Sargent's essays your reading diet is missing some spice.

JULIUS SUMNER MILLER

EXHIBIT TECHNIQUES, Edited by Helen Miles Davis. 112 pages. *Science Service.* 1951. $2.00.

This little book is intended to serve those who plan and arrange science fairs and other such displays. It discusses aids and hints to planning, exhibiting, transporting—for moving platforms, flashers, dioramas, etc. The science fair or exhibit or open house is a very worthwhile institution and should be encouraged. Often, however, both teacher and student need help in getting it going. This book provides it.

There are several excellent brief essays by persons proficient in certain aspects of this business, as, for example, an essay by Homer R. Dill (Director Emeritus, Museum of Natural History, State University of Iowa), on *Mounting of Animals.*

Instruction, information and inspiration are often gotten by seeing what others have done. Toward this end excerpts are included from the Science Talent Searches of the Westinghouse Science Scholarship program. These are worth while reading if only to see the heights to which young minds can attain. Some of these young people—the winners—write with Churchillian style, and others would do well to read their expositions aloud—and then do likewise. Indeed, I read a few lines from one such essay to a colleague who said "That sounds like Huxley," which is what I thought too.

This little book is a good two dollars worth.

JULIUS SUMNER MILLER

THE TEACHING OF MATHEMATICS, by David R. Davis, Ph.D., *State Teachers College, Montclair, New Jersey.* Cloth. Pages xv+415. 14×21.5 cm. 1951. Addison-Wesley Press, Inc., Kendall Square, Cambridge 42, Mass. Price $4.50.

The author's purpose in writing the above book is to furnish a text for a one-semester course in the techniques of teaching mathematics. It is planned for use in colleges and universities training teachers of mathematics for secondary schools and colleges. The chief aim of the book, as expressed by the author in the preface, is to exhibit clearly the problems and duties facing the modern teacher of mathematics and to suggest ways of handling them effectively.

The author begins with a discussion of the general aims of teaching mathematics. He then goes on to discuss the various classroom techniques for conducting the activities of students. He continues with a discussion of methods of arousing and maintaining interest in mathematics, and traces the changes in subject matter to the modern trend of the double-track plan in high schools. The author surveys the work in mathematics from grades seven and eight through both the traditional and non-traditional courses in high school. He surveys important principles of each course with emphasis on postulational thinking, analysis, the function concept, and understanding of the number system. Many examples are given, even to the extent that a complete teaching unit is outlined for Geometry. The treatment of principles emphasized by the author is mathematically rigorous. It is the author's purpose to have it so, since he states in the preface that he has tried to present the subject matter in such a way that the prospective teacher may learn it more thoroughly.

One chapter is devoted to tests and measurements. A survey is made of various types of tests and their uses by teachers of mathematics. Another chapter is devoted to Junior College Mathematics.

The last two chapters deal with professional duties, teacher preparation, and supervision. An outline of studies in both Mathematics and Educational Principles and Methods is suggested. Professional organizations are described and professional magazines are listed. Guiding principles of supervision for improvement of instruction are given.

The textbook should appeal to anyone interested in a rigorous presentation of mathematical principles applied to junior and senior high school mathematics. The author carries the same rigor into his suggestions for a four-year second-track program for secondary schools. Although some topics listed or discussed for both the traditional and non-traditional courses might be regarded by some as somewhat "advanced" for parts of our high school population, the author does lay out a thorough program from which to choose teaching materials.

For those who are interested in a more detailed study of special phases of the teaching of mathematics the author has a very extensive list of references suggesting reading materials in any field of interest of individual teachers.

R. M. TAKALA
Oak Park High School
Oak Park, Ill.

SCIENCE FOR MODERN LIVING SERIES, by Victor Smith, Katherine Clark, Barbara Henderson and W. E. Jones in consultation with W. R. Teeters. "Along the Way," Grade One, 128 pages. "Under the Sun," Grade Two, 160 pages. "Around the Clock," Grade Three, 160 pages. "Across the Land," Grade Four, 192 pages. "Through the Seasons," Grade Five, 224 pages. "Beneath the Skies," Grade Six, 224 pages. J. P. Lippincott Co. (see S.S.&M. LI (October 1951), p. 585 for complete description).

The six books included in the "Science for Modern Living" series are well written science readers organized on the basis of subject matter for grades one through six. The colored and black and white illustrations are eye catching and should prove effective in helping children understand more completely the narrative portions of the books.

Units or topics dealing with different phases of plant and animal life are found in each of the six books. Book One stresses getting acquainted with plants and animals, i.e. what they eat, how they move, where they live, how they are affected by the changing seasons, animal babies, and seeds. Book Two stresses the dependence of animals upon plants, animals as food, manufacture of food by plants, storage of food by plants, living things and water, and birds. Book Three emphasizes plant parts, uses of plants, growth needs, insect homes, insect life cycles, insect food, and reproduction in plants, i.e. seeds, bulbs, and cuttings. Book Four stresses prehistoric plants and animals, planning an aquarium, trees, spring flowers, planning a garden, insect pests, birds and reptiles. Book Five discusses to some length the effect of the changing seasons on living things and the adaptation of living things to these changes, microscopic plants and animals, non green plants, cells, protecting plants from insect pests, birds, farm animals, and the life of the bee. Boox Six includes many of the previously noted topics as well as plants without seeds, structure and function of plant parts, insects and plants, pond life, and the adaptation of living things to their environment.

Throughout the six books there is evidence of the progressive development of the concept of the interdependence of plants and animals. Considerable emphasis is also placed upon the direct observation of living things.

The area of health, though not always directly approached, is considered in all of the six books. Book One points up the wearing of appropriate clothing; Book Two makes note of the need for good food, sunshine, fresh air and good water; Book Three refers to pasteurized milk and body temperature; Book Four includes heating and lighting our homes and safety in using electricity; Book Five notes only the sanitary way in which cows are milked; and in Book Six there is a complete unit including problems in both personal and community health.

The areas of seasons or weather and some concepts referring to the planets, sun, moon or stars are included to a degree in all six books.

Chemical and physical changes in matter, though usually restricted to water, are discussed in Books One, Two, Three, Five and Six; Magnetism and/or electricity is included in Books Two, Four and Six; Machines in Books Three, Four and Five; Heat and its transfer are most completely developed in Book Four; and Light and Sound, though mentioned in some of the other books are most elaborately treated in Book Six.

It is noted that the areas of plants and animals are continuous and developmental and that this is not true in most other areas. This may be an asset or a liability depending upon the philosophy of the school utilizing the books. Although there is evidence of an attempt on the part of the authors to utilize the inductive method of learning, the method most predominant in these books is deductive.

MILTON O. PELLA
University of Wisconsin

Scientific Law is description, not a prescription.—Karl Pearson.